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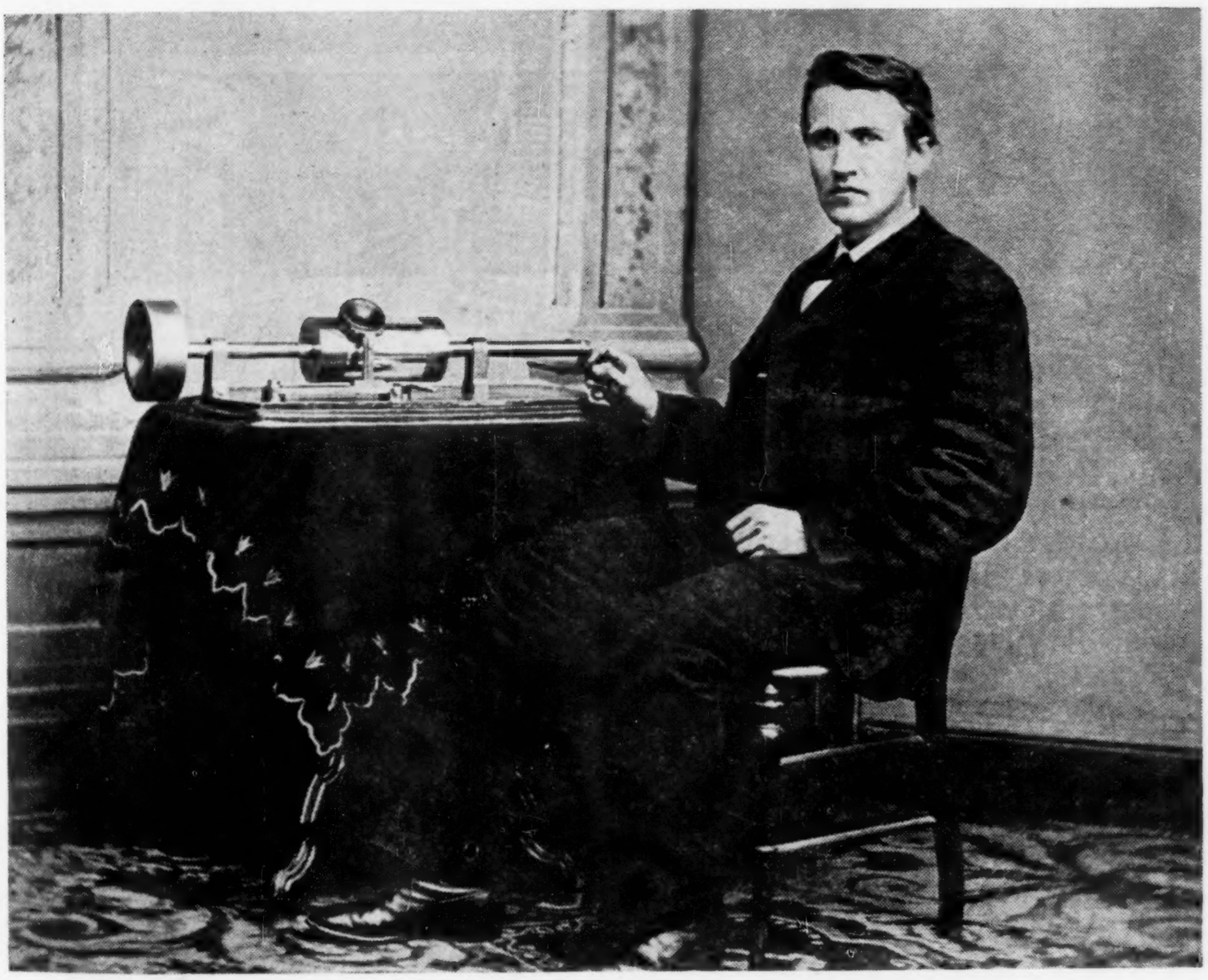

A Matthew B. Brady photograph of Thomas A. Edison and the "talking phonograph," taken April 18, 1878, when Edison demonstrated the device before the National Academy of Sciences in Washington.

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Thomas A. Edison Centennial Issue

Science

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Thomas A. Edison:
Sketch of Activities, 1874–1881

Norman R. Speiden, *Curator,*
Laboratory of Thomas A. Edison, West Orange, New Jersey

About 10 years ago a project was started to provide permanent care for the records and instruments in the Laboratory of Thomas A. Edison, at West Orange, New Jersey. One of the first requirements was cataloguing the library of approximately 10,000 volumes, most of which had been purchased by Edison in connection with his numerous investigations. This cataloguing took a little over two years, and in the process a number of interesting volumes were discovered, many of them containing marginal notes made by Edison.

Among the discoveries was a bound copy of the first volume of *Science* covering the six-month period, July 3-December 31, 1880. The true significance of this discovery was not realized until several years later, when we began to read and file the old correspondence which for 50 years or more had remained tightly folded and packaged in several dozen small wooden boxes, apparently just as it had been packed for shipment from Menlo Park to West Orange about 1887. In this correspondence we discovered letters, for the most part received by Edison from John Michels, first editor of *Science*, revealing that Edison had undertaken to finance publication of the magazine for one year beginning in the spring of 1880, and had, in fact, continued to do so until the last issue of 1881, 18 months later. The issues of 1881 are not in the library.

Pasted on the back cover of an old scrapbook discovered in Edison's library was the following telegram on the letterhead of the Automatic Telegraph Company, George Harrington, president, and J. C. Reiff, secretary and treasurer:

Philadelphia, November 4, 1874

T. A. Edison
Newark

The National Academy of Sciences, Professor Henry, President, is now in session at the University of Pennsylvania in this city. Will you come on either Wednesday or Thursday and exhibit your remarkable electromotograph to them? Letter by mail.

George F. Barker
Editor, Franklin Institute Journal

Farther back in the body of the book was found the letter to which the telegram referred:

Journal of the Franklin Institute
Editor's Office
Philadelphia, Nov. 3, 1874

My dear Sir:

It occurred to me while examining the remarkable little instrument of yours—the motograph—at the Franklin Institute Exhibition this evening, that perhaps you would be willing to come on and show it to the highest scientific body in this country, The National Academy of Sciences, of which Professor Henry is President, now in session in this city. Mr. Patrick was good enough to say he would send you a message from me and I wrote one. I send this letter to explain matters more fully.

The first notice I saw of your curious discovery was in the London Journal of the Telegraph. I at once became very much interested in it, as a scientific fact of very important bearing in many directions, and I have had it in mind ever since to write

This issue of *Science* is dedicated to the commemoration of the centennial of Thomas A. Edison's birth on February 11, 1847 at Milan, Ohio.

A visit made to the Thomas A. Edison Laboratory at West Orange, New Jersey, while plans were being made for the issue, disclosed some little-known facts about the relationship between the founding of this magazine and Thomas Edison's busy life in 1880 and the years immediately preceding that time.

Evidence is presented here that Edison found time to establish a weekly journal for American scientists which would, in the American scene, fill the position occupied by *Nature*, which had been established in 1869 in England.

The evidence seems to be clear cut in showing that the founding of *Science* wil. have to be pushed back from 1883, when the magazine appeared as Volume 1, Number 1, to 1880, when there was also a Volume 1, Number 1.

and ask you to prepare me an article for this Journal describing it and if possible, illustrating it. This request I have now to make. If you really cannot do it, can you not place me in possession of the facts and material so that I can make up a paper on it.

I am very anxious too that the Franklin Institute should recognize the merit of this discovery and properly reward it. As a member of the Board of Managers I shall be very glad to do what I can toward this end. So that if you can make it convenient to come on either tomorrow or Thursday, there are several matters we can profitably talk over.

I am Professor of Physics in the University of Pennsylvania (Locust & 34th Sts.) and shall be glad to see you there when you come, or at my house, 408 S. 41st St.

Trusting that you may be able to run down here for a day and see us, I remain

Truly yours,
George F. Barker

T. A. Edison, Esq.

We know from a letter he wrote on November 8 to his father in Port Huron, Michigan, that Edison attended the session of the National Academy of Sciences and demonstrated his electromotograph. Although this discovery did not become very well known, its application several years later to the telegraph brought Edison $100,000, which he characteristically insisted on receiving at the rate of $6,000 a year for the 17-year life of the patent. This was his method of financing his research over a long period, for he knew if he received the money all at one time he would in all likelihood spend it much faster. About four years later another application of this electromotograph principle was made by Edison in his chalk telephone receiver. This brought him more than $100,000.

In the meantime, however, Edison had grown tired of the limitations imposed on him by his many manufacturing interests in Newark and had left these in the hands of associates, building himself a new laboratory at Menlo Park, New Jersey, where he could be away from the distractions of city life but at the same time approximately halfway between New York and Philadelphia. The construction of this laboratory, started in January 1876, seems to have strained his resources, and he was apparently somewhat short of cash until the invention of the phonograph in August 1877. Although it was at that time a very imperfect recording and reproducing instrument, it took the public fancy, and on April 18, 1878, Edison again was asked to demonstrate the new machine before a meeting of the National Academy of Sciences in Washington.

Edison persuaded his assistant, Charles Batchelor, to accompany him to Washington, and as they descended from the train, Edison wearing a new suit of checkered pattern (see cover), the two were met by Uriah Painter, well-known newspaper correspondent, bearing news that Gail Hamilton, niece of James G. Blaine, wanted the instrument brought to her apartment to show some of the prominent members of Congress and the diplomatic corps, and that later President Hayes wanted it demonstrated at the White House.

After breakfast at the Willard, they drove to the home of Joseph Henry, secretary of the Smithsonian Institution, and demonstrated the machine in his parlor. In the late afternoon they arrived at the meeting of the Academy, where a recording was made in which the speaking phonograph, as it was then called, expressed thanks for the honor of being requested to present itself before the Academy. After making the recording, Edison left the room and allowed the crank of the machine to be turned by his assistant to prevent a repetition of what had occurred at a demonstration of the machine before the French Academy, when several of the French scientists left the room in indignation because they believed they were being fooled by a ventriloquist. Edison's friend, Prof. Barker, followed with a paper describing Edison's achievement in transmitting speech over 140 miles by means of his carbon telephone transmitter and induction coil. It was nearly midnight when word came that President Hayes was ready to see the machine and nearly 3:00 A.M. before Edison left the White House.

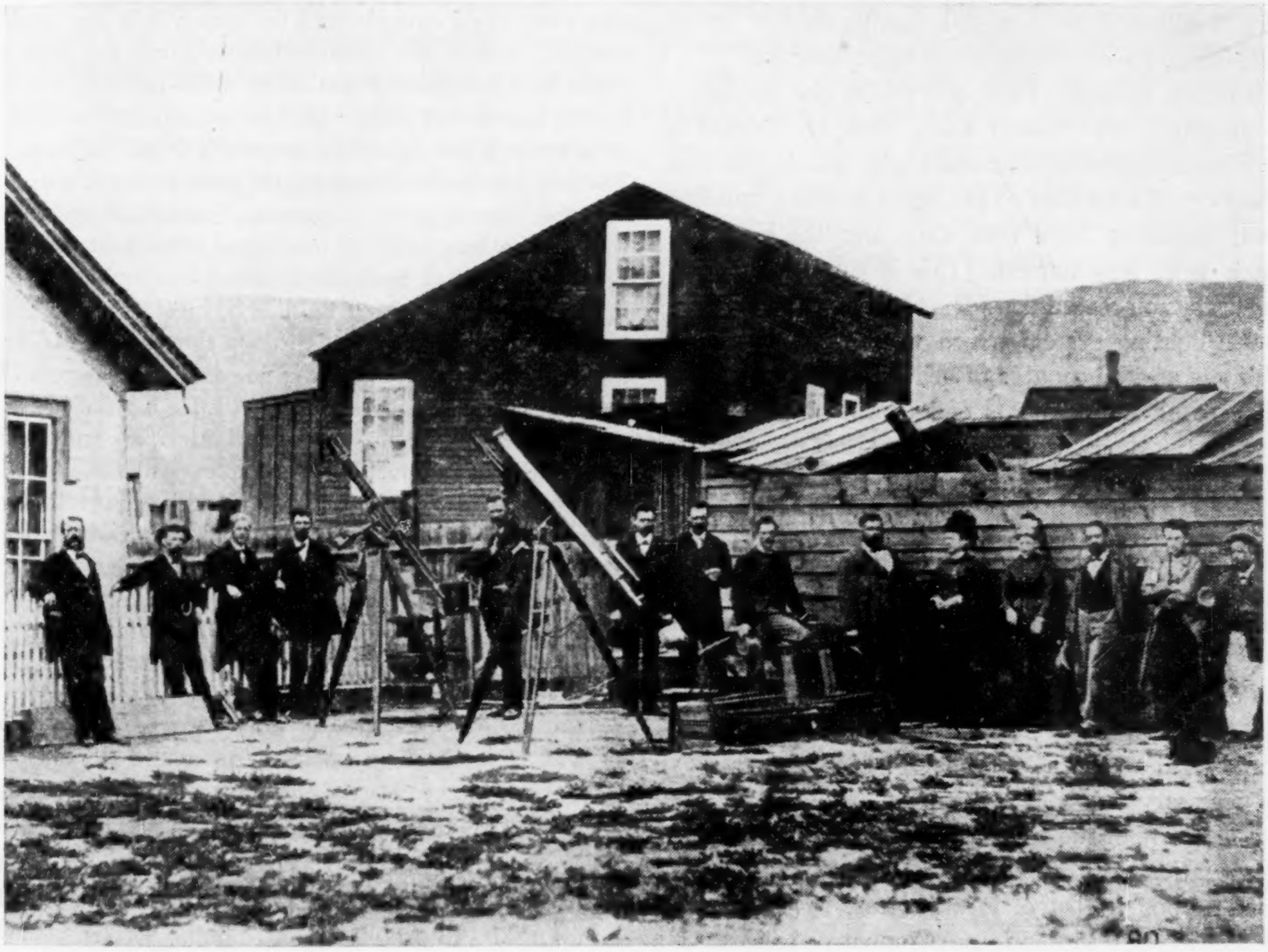
As the warm weather of summer approached, Edison, who apparently showed signs of strain from not having had any relaxation for many years, was persuaded by Prof. Barker, no doubt with the assistance of Mrs. Edison, to take a real vacation. The scientific world was preparing several expeditions to observe an eclipse of the sun which was to occur on July 29, 1878, the path of totality crossing Wyoming and Texas. Of course, it was hard for Edison to justify taking a vacation without accomplishing something, so he took with him his recently developed microtasimeter—an instrument utilizing the varying pressures produced by the expansion of a hard rubber rod on a carbon microphone. In this way, extremely slight variations in temperature could be indicated electrically on the dial of a galvanometer. Prof. S. P. Langley, of Allegheny University, had suggested the device to Edison, and it is interesting to note that it was afterward superseded by Langley's Bolometer utilizing the varying electrical resistance of selenium for the same purpose.

Edison left Menlo Park early in July, armed with the microtasimeter and also a pass obtained through the courtesy of Mr. Jay Gould, who then controlled the Union Pacific, allowing Edison to ride on the cowcatchers of the locomotives. We do not know whether Prof. Barker traveled with Edison, but he was one of the group that assembled at Rawlins, Wyoming. This group also included Prof. Henry Morton; Prof. James C. Watson, director of the observatory at Ann Arbor, and Mrs. Watson; Prof. Henry Draper, previously of New York University, and Mrs. Draper; and Prof. J. Norman Lockyer, British astronomer and founder of *Nature*.

Prof. Samuel P. Langley observed the same eclipse at Pikes Peak, Colorado, and Prof. Asaph Hall at La Junta, Colorado. Edison's roommate at Rawlins was Marshall Fox, correspondent of the New York *Herald*, who several years later was to scoop the world on announcement of the successful incandescent lamp.

The details of the various expeditions, all of which were successful, are covered in a large volume published by the U. S. Naval Observatory, but for our purposes this among the group and, after the immediate work of observing the eclipse was completed, Edison, with Prof. Barker, Major Thornberg, and several soldiers, went hunting in the Ute country about 100 miles south of the railroad. A few months later, the Major and 30 soldiers were ambushed near the spot at which the hunting party had camped, and all were killed.

Edison continued his trip West, visiting Virginia City and Yosemite, and meeting a few of his old cronies of



The Draper Eclipse Expedition. Left to right: George F. Barker, University of Pennsylvania, editor of the *Journal of the Franklin Institute*; Robert M. Galbraith, master mechanic, Union Pacific Railroad; Henry Morton, president, Stevens Institute; —— Bloomfield; —— Meyers; D. H. Talbot, Sioux City; M. F. Rae; Marshall Fox, New York *Herald* correspondent; James C. Watson; Mrs. A. H. Watson; Mrs. Henry Draper; Henry Draper; Thomas A. Edison; and J. Norman Lockyer, editor of *Nature*, London.

expedition was important because it stimulated Edison, through contacts and observations made on the trip, to a consideration of the many ways in which electricity could be utilized in opening this territory. Edison observed that there were vast regions so inadequately supplied with steam railroad facilities that it was necessary in many places to haul grain 200 miles or more by horse and wagon for shipment by railroad to the East. This observation resulted, on his return, in building of the first experimental electric railroad at Menlo Park to demonstrate the feasibility of electric railroads as a system of feeders for steam roads (see *Science*, 1880, p. 5).

There must have been many interesting conversations telegraph days. He arrived at Yosemite about the middle of the afternoon, rode to the top of Glacier Point, went down the trail after dark, and started for Mariposa the next morning, proudly asserting that only one man had beaten his time—Horace Greeley. Greeley reached the valley after dark and left it before daylight.

Edison was much impressed by the difficulty experienced by miners in drilling and boring. Watching them, he turned to Prof. Barker and asked: "Why can't the power of that river be transmitted to these men by electricity?" On the way home across the plains, the idea grew on him and, in discussing it with Prof. Barker, plans were made to visit the latter's friend, William Wallace, a

manufacturer of electric dynamos and arc lights, at Ansonia, Connecticut.

The party arrived home late in August, and on September 8, Prof. Barker, Prof. Charles Frederick Chandler of Columbia University, and Edison went to Ansonia. In their honor Wallace had connected his most recent dynamo and lighted eight arc lamps. Edison was greatly interested and went from one apparatus to the other, making calculations of the power of the machines and amount of light produced. Before leaving, he said to Wallace: "I believe I can beat you making electric lights. I don't think you are working in the right direction."

On his return to Menlo Park, everything else, including the phonograph, was tossed aside, and he started a thorough investigation of illumination by gas. He made a careful survey of a number of gas lights in every building in several blocks of New York City and the length of time each light was burned. [This is one of the first market surveys on record. Ed.] His object was to produce an electric lighting system which would have the simplicity of gas and be capable of general distribution and adaptable to all requirements of natural, artificial, and commercial conditions. It was necessary that the lamp be simple and light in weight, cheaper than gas, noiseless and inoffensive, and distinguishable from all previous types of electrical illumination in that it must be possible to turn each light on and off individually. In fact, this was the real problem in his system of lighting, and was known in scientific circles at that time as the problem of "subdivision of the current."

From this time on things moved speedily. Edison's friend and legal adviser, Grosvenor P. Lowrey, arranged for the necessary financial backing for incorporation, on October 24, 1878, of the Edison Electric Light Company. The corporation was a Wall Street organization and contained among its list of incorporators several of the firm of J. Pierpont Morgan and Company. Half of the $300,000 capital was made available to Edison to equip his laboratory for investigation. Three days short of a year from this date the first successful incandescent lamp burned out its 40 hours of life at Menlo Park. In the December 21, 1879 issue of the New York *Herald*, a full-page article by Marshall Fox announced the successful lamp to the world.

During this year, Edison not only solved the problems connected with the lamp but also produced the first electric generator with an efficiency exceeding 50 per cent. The efficiency of the 1879 generator was rated at over 90 per cent. Technicians had assured Edison that an efficiency of over 50 per cent was theoretically impossible, just as scientists of England had testified before a parliamentary investigating committee that it was impossible for Edison to solve the problem of subdivision of current. The only known exception among the scientists was Prof. John Tyndall, who, in his address on the electric light before the Royal Institution on January 17, 1879, gave evidence of a thorough understanding of the relationship between the pure scientist and the inventor when he said:

> It was my custom some years ago, whenever I needed a new and complicated instrument, to sit down beside its proposed constructor, and to talk the matter over with him. The study of the inventor's mind which this habit opened out was always of the highest interest to me. I particularly well remember the impression made upon me on such occasions by the late Mr. Becker, a philosophical instrument maker in Lambeth. This man's life was a struggle, and the reason of it was not far to seek. No matter how commercially lucrative the work upon which he was engaged might be, he would instantly turn aside from it to seize and realize the ideas of a scientific man. He had an inventor's power, and an inventor's delight in its exercise. The late Mr. Becker possessed the same power in a very considerable degree. On the Continent, Froment, Breguet, Sauerwald, and others might be mentioned as eminent instances of ability of this kind. Such minds resemble a liquid on the point of crystallization. Stirred by a hint, crystals of constructive thought immediately shoot through them. That Mr. Edison possesses this intuitive power in no common measure is proved by what he has already accomplished. He has the penetration to seize the relationship of facts and principles, and the art to reduce them to novel and concrete combinations. Hence, though he has thus far accomplished nothing that we can recognize as new in relation to the electric light, an adverse opinion as to his ability to solve the complicated problem on which he is engaged would be unwarranted. . . . Knowing something of the intricacy of the practical problem, I should certainly prefer seeing it in Mr. Edison's hands to having it in mine.

Had Edison been greatly impressed by the statements of well-recognized authorities, he would perhaps never have continued his experiments on distribution of electricity for light and power, but he had a firm hold on general principles and was perhaps luckily unaware of some details which seemed to indicate to more theoretical minds that the problem could not be solved. One of his favorite observations was that when he started to work on a problem he was told it could not be done, and after the problem was solved many people claimed priority.

Marshall Fox's article in the New York *Herald*, December 21, 1879, announced that on December 31 Edison would give a public demonstration of the light at Menlo Park. The announcement apparently put the Laboratory on a spot, for there was a great deal of rushing around in preparation for the exhibit scheduled in 10 days. However, on that New Year's Eve, everything was ready. Special trains were run to Menlo from New York and Philadelphia, and those who visited the demonstration considered it well worth their time. It is regrettable that no registry was kept of the visitors, but we know that many prominent people were there.

The filaments used in this demonstration were carbonized cardboard filaments, whereas that used in the original lamp was a carbonized sewing thread. Still, Edison did not believe he had the best possible form of

carbon for his lamps. Early in 1880 he hit on the idea of using bamboo, as this was one of the few substances in nature with a perfectly straight grain long enough to be used as a filament, and he immediately instituted a search throughout the world to find the best possible bamboo fiber for the purpose.

During this year he also introduced new and more efficient generators and worked on the design of meters, fuses, sockets, switches, electrical conductors, and many other items necessary for installing lighting in the first district of New York.

The cost of the electric light was a foremost question. Edison was asked this question many times every day, and, since whatever he or his mathematician, Francis Upton, said was immediately pounced upon by other mathematicians and proved wrong, the inventor invited his friend, Prof. Barker, and three other scientists to visit the Laboratory, measure the lamp, and give an unbiased report. The favorable verdict was presented to the world by Prof. Barker in a lecture before the Franklin Institute, Philadelphia, March 24, 1880.

In May of this year, the first commercial installation of Edison's light was made on the steamship *Columbia*, which pessimists predicted would burn before it rounded Cape Horn. However, the original installation, with no changes other than the replacement of lamps, remained in satisfactory operation for 15 years.

In the meantime Edison's assistants at Menlo had been laying track and designing engine and cars for the first electric railroad, which went into operation May 13.

Also, many installations were made in local hotels, theaters, and private mansions at this time. These were known as isolated stations as contrasted with central stations for commercial distribution.

The Edison Electric Light Company wanted to remain simply a holder of patents and licensor of installations of the Edison system, and not go into manufacturing. For manufacture of machines and tools as well as lamps the Edison Lamp Works was established at Menlo Park on October 1, 1880, and a year later moved to Harrison, New Jersey, present location of the General Electric Company's plant. Most electric fixtures, such as sockets, switches, and chandeliers, were made by one of Edison's old Newark associates, Sigmund Bergmann, in his shop at 17th Street and Avenue B, New York. For manufacture of underground conductors, a plant known as the Electric Tube Company was set up at 65 Washington Street.

The early dynamos and motors were made at Menlo Park, but with the Jumbo dynamo, facilities at Menlo were soon overstrained, so in the early part of March 1881, Edison and his newly-arrived secretary from England, Samuel Insull, leased for the Edison Machine Works the plant of the Aetna Iron Works, 104 Goerck Street, New York. It was here the Jumbo dynamos were made for subsequent central stations. These machines were the first electrical generators directly connected on the same shaft with the steam engine which drove them, and it was necessary to have a steam engine especially designed by the firm of Armington and Sims. Total weight of dynamo and engine was over 30 tons. The first of these dynamos was shipped to the Paris Exposition of 1881.

On October 21, 1881, exactly two years after birth of the first successful lamp, the Conservatory of Music in Paris was crowded with a distinguished gathering of officials, jurors, commissioners, cabinet ministers, exhibitors, and the general populace, to witness the awards of the Paris Exposition. Edison's first knowledge of his sweeping victory came by cable: "Official list published today shows you in highest class of inventors. No other exhibitor of electric light in that class. Swan, Lane-Fox, and Maxim received medals in class below. The sub-jury had voted you five gold medals but General Congress promoted you to the Diploma of Honor. This is complete success, the Congress having nothing higher to give."

This was followed by a cable from Prof. Barker, United States representative on the Commission of Judges, who nearly a year previously deserted Edison and said of Maxim: "For years I have been an admirer of Edison's search for the true solution of the electric light problem, and I can testify to the unremitting energy and exhaustive nature of his search, but another man found it." In contrast with this statement, his cable from Paris read as follows: "Accept my congratulations. You have distanced all competitors and obtained a Diploma of Honor, the highest award given in the Exposition. No person in any class in which you were an exhibitor received a like award."

Although we have covered only a few years of Edison's life, they were extremely active, and the nature and quantity of work demanding his attention during the inception of *Science* show why he was able to give little attention to its editorial policy and why most of the correspondence and business was carried on by his assistants, Samuel Insull and S. L. Griffin.

I believe Edison's agreement to finance the magazine for a short period is explained by a philosophy he developed at the time of his first invention, for which there was no demand. From that time he determined never to waste time and energy on a thing not commercially needed, and he believed definite need for a project would insure its success.

One of the early letters relating to *Science* stated it was to fill the place in this country served by the magazine *Nature* in England, and it is perhaps worth while to note that Prof. J. Norman Lockyer, who was on the Eclipse Expedition, was founder of *Nature* and its editor for many years. There is, therefore, a possibility that some of the conversations on this vacation trip were responsible for the origin of *Science*.

Thomas A. Edison and the Founding of *Science*: 1880

DOCUMENTS RECENTLY UNCOVERED in the Thomas A. Edison library at West Orange, New Jersey, show clearly for the first time the relationship between a journal, *Science*, published in New York in 1880 and 1881, and the present *Science*.

Volume 1, Number 1, of the present *Science* begins with the issue of February 9, 1883, and continues in unbroken sequence, although under different ownership and with some lapses in publication, until the present time.

It has long been known that the first decade of this series was under the sponsorship of the Alexander Graham Bell family and that after 1895 and until 1944 under the ownership of the Cattell family.

In 1926 J. McKeen Cattell, then editor of *Science*, wrote that in 1881 and 1882 there had been published in New York "a weekly journal devoted mainly to physical science and invention, entitled *Science*, and Mr. [A. Graham] Bell purchased from Mr. John Michels for $5,000 the title and good will of this journal. Continuity of the publication was not, however, maintained, and the present journal [*Science*] dates from 1883. Mr. Thomas A. Edison had been responsible for the foundation of the earlier *Science*" (*Science*, 1926, **64**, 343).

Dr. Cattell continues, presumably quoting from a letter written to him by Thomas Edison in 1925: "If you will look back at your earliest records, you will find that *Science* was originally started and financed by me and was published for about a year, when I withdrew . . . [ellipsis Dr. Cattell's]. When I could not finance the publication further, I paid the editor's salary in full and told him he could have the paper and do what he pleased with it."

Whether Dr. Cattell had ever seen the early *Science* we do not know, but he places its publication in 1881–82 rather than 1880–81 and describes its contents incorrectly.

Norman R. Speiden, curator of the Laboratory of Thomas A. Edison at West Orange, has during the past few years slowly been making available to qualified students materials in the Edison collection. The letters written by Edison or his secretaries were handwritten during this period and copies of them preserved by the old-fashioned copybook method. Letters received by Edison are usually folded and so brittle they have to be specially treated before they can be unfolded and inspected. Most of these also are handwritten, so that deciphering them is a somewhat laborious process. Mr. Speiden has made this material available to the editorial staff of *Science*, and it has been studied during the past few months in an attempt to piece out the early history of the magazine.

Thomas Edison never was the editor of *Science*, as has sometimes been said. From 1879 through 1881 he was much too busy with the development of the electric lamp and its attendant problems to concern himself with the active editorial direction of the new magazine. Mr. Speiden's article in the preceding pages gives the background of Edison's life at this time, pointing out that he had known J. Norman Lockyer, founder of *Nature*, during the Draper eclipse expedition of 1878 and that possibly they had talked about an American *Nature*. It is clear, however, from the records that, aside from paying the bills, he took an active interest in the journal, received weekly reports from the editor and advance issues of the magazine, on one occasion spoke his mind about an item of editorial content, and asked whether he could see manuscripts or proofs of them before they went to press when these touched on matters of electrical engineering, with which he was most conversant.

The first letter in the collection is dated April 17, 1880, and is written to Thomas Edison at Menlo Park, New Jersey, by John Michels of Room 10, 767 Broadway, New York. It begins:

> I am thinking of taking action about the establishment of a strong Scientific Journal, and intended to have made you a visit to renew my conversation with you on the subject, but having been confined to my room this week have not had the opportunity.
>
> I think you said that when you were further advanced you would cooperate with me. I notice you will shortly make another move forward, and I now suggest that something be done.
>
> There could not be a better time for literally the field is open for with the exception of Patent office organs, and journals limited to particular to particular [*sic*] interests, there is nothing in the market, and English Journals are establishing good subscription lists here in consequence.

The letter goes on to outline the editorial content of the journal Michels had in mind and mentions that he had been in correspondence with Prof. Burt Wilder of Cornell about such a magazine and had received from Prof. Wilder a possible subscription list. The letter ends with the hope that the writer would be able to see Edison within the next few days about financial backing for the proposed magazine.

The occasion upon which these early conversations took place is not indicated, but John Michels describes himself as an editorial writer for *The New York Times* and a contributor to Appleton's *Popular Science Monthly*. He was probably at this time a free-lance writer with a

newspaper background; and in an unsigned article in the March 4, 1882 issue, the last under his supervision, he says that he lived for many years in London. He tells of a visit to Menlo Park in the spring of 1878, when Edison was testing the tasimeter prior to the Draper eclipse expedition (*Science*, 1880, September 4), and from the correspondence we can infer that he either had been to Menlo Park or had seen Edison in New York on other occasions prior to April 17, 1880.

In any event, the record next shows that Michels was directed by Edison to draw up a prospectus of the new journal. Several copies of this prospectus in Michels' handwriting, duplicated by a gelatin method, are in the Edison files together with a letter from Michels dated April 27, 1880. The prospectus announces the desirability of forming a small company to publish an "American Scientific Journal" directed toward a large circulation. The interest of the public in scientific subjects is mentioned and the hope expressed that the magazine will be "sold on every newsstand in the United States, indispensable to every man of intelligence who would be posted on human progress."

If we can reconstruct the situation, it would appear that the public interest in "scientific" events in 1880 closely paralleled the public interest in "scientific" events of our time; and where we have seen the introduction of several new scientific publications directed toward mass consumption, in 1879 and 1880 the field was relatively clear; where today there are several attempts to exploit this market, in 1880 only one new journal that we know about was proposed.

Among names advanced for the new journal were *Nature (American)*, *Popular Science Weekly*, and the *Intellectual Observer*. Who finally chose the name *Science* for the new magazine is not explicitly stated, but the first mention of the name occurs in an unsigned "Memorandum Agreement" in Edison's handwriting between Thomas A. Edison and John Michels, dated June 1880, but with the day left blank. This agreement will be treated in more detail later in this text, because, while unexecuted, it briefs the actual events of the next 18 months as they are documented in the correspondence.

The prospectus fixes the size of the journal at approximately 9 x 13 inches and provides for an index but does not state how many volumes there would be each year or how many pages each number would contain.

The content is specified in detail, particular weight being given to "two Editorials on current matters of interest, as often as possible by men of known ability on that particular subject." Provision was made for the appearance of current scientific information under specific headings such as "Electricity, Mechanics, Chemistry"—in the language of the prospectus, "not mixed up as in most Journals." It was also planned to appoint correspondents in foreign countries whose dispatches to the magazine would be headed "Germany, France, Italy, etc." "Proceedings of societies at home and abroad, government surveys and expeditions," are given explicit mention. It is said that current social subjects connected with science, such as "public health, sanitary science, etc.," would be printed in the interest of the general public, and it is specified that "no attempt will be made for pictorial effects" but that illustrations would be used where necessary.

It predicts that the new magazine will command "special patronage as an advertising medium for books, scientific instruments, foreign manufacturers and for all goods used by the best classes of Society." The prospectus estimates that such a journal could be produced for a capital of $12,000, or 120 shares at $100 each. It suggests that if five persons should take 20 shares apiece, the editor should be given his 20 shares in addition to a reasonable weekly salary. No estimate was made of either income or expenses.

Edison acknowledged receipt of the prospectus in a letter dated April 29, 1880, and signed by S. L. Griffin, his secretary at Menlo Park. "Mr. Edison requests me to say," the letter says, "that if satisfactory arrangements can be made, he will take the 20 shares. He wishes to consult some friends in New York and endeavor to get them interested also."

There is no record of Edison's attempts to interest his "friends in New York." On May 6, however, Michels wrote to Edison telling of some conversations he had had with a Mr. Shonnard, described as "a gentleman of large property and considerable influence," who recommended that $10,000 would hardly be enough capital to start the venture and suggested $25,000, and who wanted to take advantage of the Edison name to insure success of the venture. The conversation with Shonnard resulted in a conference between Shonnard, Michels, and a Mr. Jewett, described as publisher of, among other items, *Uncle Tom's Cabin*. The publisher's interest in the venture seems to have been to secure publishing rights to any book that might develop as a result of the manuscripts published in the new journal. The closing paragraphs of the May 6 letter follow:

> Mr. Shonnard feels the power of your name and influence and wishes to know from you clearly, that it is to be considered your organ, as he considers that fact will insure its sale largely—
>
> If you consent to this, please state when you can spare an hour to talk the matter over with Mr. Jewett either on Saturday next or early next week.

Presumably, Edison did not react favorably to the Shonnard proposal.

The next item in the record is the unsigned memorandum of agreement between Edison and Michels, mentioned previously. Essentially, this agreement made Michels an employee of Edison at a salary of $30 a week for one year, empowered him to pay for an assistant at a

salary of not more than $15 a week, and charged him with the responsibility of placing the enterprise on a paying basis within the year. Edison agreed to pay all of the bills, but required that no debts be entered into without consent in writing. Except for the fact that the unsigned agreement was in force for 18 months rather than one year, the terms of the agreement closely parallel the actual happenings. For the first six months payments from Edison averaged a little more than $100 a week, and in the next year were nearer $150. Throughout the period the expenses were detailed to the last postage stamp. The method of accounting was a simple one—office receipts were balanced off against expenses, and Edison sent a weekly check for the deficit.

The next document of interest is a lease for Room No. 53 on the fifth floor of the Hamilton Building at 229 Broadway, New York, which was rented to Thomas A. Edison from June 7, 1880, to May 1, 1881, at $20 a month in advance. The provisions of the standard lease allowing a charge for heating and janitor service were stricken out of the agreement and a notation made that there should be no charge for these services. The lease was signed on June 3 by an attorney for the owner of the building and by Thomas A. Edison personally. Edison's name does not appear in connection with the printing bills or other items of expenditure, all of which were conducted by Michels in the name of the journal. At the end of the lease period, Michels refused to pay an additional $5.00 per month rent which the lessor wanted and moved the office to Room 17 of the Tribune Building, where it remained until the journal suspended publication.

The first issue of the magazine, *Science: A Weekly Journal of Scientific Progress*, consisting of 12 pages and cover, appeared July 3, 1880. This format continued for the whole period of the first volume, which ended with the December 31 issue. In each issue advertising displays occupied the front cover. At first these were of the small type we now call classified advertising, but beginning in September the front page was devoted to the Stylografic Pen, "a pencil that writes ink, never needs sharpening and never wears out," while the classified advertising was relegated to the back cover, a position previously devoted to advertising *Science*.

The first issue contained an account of the accomplishments of the U. S. Naval Observatory at Washington and two other articles preceding the editorial page. One of these, on page 5, was an article on "Electricity as Power," by Francis P. [R. is correct] Upton, Edison's mathematician at Menlo Park and a former student of Helmholtz. The forepart of the article is theoretical, and the latter describes the electric railroad at the Park. The latter part of the magazine was devoted to the divisions of science noted before—natural history, microscopy, physical notes, chemical notes, etc.—changing from issue to issue. No mention of Edison's support was published anywhere during the first 18 months, but in the editorials Edison is defended on half a dozen different occasions. In the issue of July 10, 1880, the editor writes:

> A gas lighting and sanitary journal published in London asserts that Mr. Edison has thrown up his electric light researches and left for California, and suggests that there is now a fair field for those disposed to try their hand in this direction.
>
> Possibly the "*wish*" was father to the "*thought*" with the promoters of this journal, when they printed this atrocious statement, which is not only false but malicious.
>
> In this country a contradiction of such a "*canard*" is, of course, unnecessary. Mr. Edison has ceased to notice attacks of this nature, and possibly in his retirement at Menlo Park, and with every moment occupied on his important work, he may not even know of them. Warned by the experience of the misinterpretation placed upon his willingness to permit the public to witness the progress he was making with his carbon-electric lamp, he has of late discouraged the continued reporting of his movements, but within a very few weeks a whole section of Menlo Park will be illuminated by means of his carbon-electric lights, equal in extent to one of those districts which will afterwards be established in New York City if success is achieved. . . .
>
> This will be Edison's answer to all the meretricious arguments and scientific hair-splitting which has been of late, with little generosity, carefully disseminated to his disadvantage. Taking the view that it is a waste of time to argue theoretically, on that which can be demonstrated practically, Edison, through all this wrangle has been silent, but not idle; while others *talked*, he has *worked*, and in a few short weeks all will be ready, when those who are competent can see and judge for themselves.

Considering the position that Edison held in the engineering world in 1880, subsequent to announcement of the successful electric lamp in December 1879, no undue amount of space was devoted to his defense. As a matter of fact, more space was given editorially to the AAAS Boston meeting of August 25, 1880, than was devoted at any time to Edison. The editor promised that abstracts of all the papers would be printed in *Science* and that a large number of the papers would be given prominent lead positions. The editor attended the meeting in Boston and in the issue of August 28 stated in a short note that his next issue would contain the complete address of the retiring president of the Association, George F. Barker. Almost exactly two-thirds of the issue of September 4 was actually devoted to the Boston meeting. Among the events scheduled for that meeting was a reception at the home of Mr. and Mrs. Alexander Graham Bell in Cambridge. It is perhaps no accident, then, that the next issue contained an editorial on the photophone and an illustrated abstract of a paper which Bell had presented at the Boston meetings. There is some evidence that Bell and Michels had been in correspondence about this abstract even before the meeting.

As Mr. Speiden's article shows, Edison's life was a busy one at this time, when preparations were being made for

the Paris Exposition, so that whether he was really aware of the journal is questionable. The weekly checks were signed by his bookkeeper, and most of the correspondence was actually produced by either one or the other of two secretaries. There is evidence in the correspondence, however, that Edison was keeping close watch on the editorial content. Near the latter part of September 1880, Edison complained that he had not been getting his advance copy. A letter from Michels addressed to S. L. Griffin at Menlo Park and dated September 27 says: "I will in the future duplicate Mr. Edison's early copy. I have always sent him six copies following the first early one and 25 to you for general use."

Additional evidence is found in a letter signed by Edison personally and apparently dictated by him which speaks for itself and is reproduced here in its entirety:

John Michels, Esq.
N. Y.

Dear Sir:

In the last issue of Science (Oct. 2d) I notice a great deal of space given to Weisendanger. Now I don't suppose you are aware of it but in Europe Weisendanger is looked upon as little less than an idiot and such stuff as the article referred to is nothing more nor less than a disgrace to a scientific paper. If such a thing is possible I would like to see the proofs of what is to appear in Science before the paper is published and thereby avoid as much as possible that which would be detrimental to its interests.

Very truly
T. A. Edison

The paper referred to, "An Improved Electro-motor," was an illustrated article printed in *Science*, 1880, October 2, pages 170–172, and the editor mentions that it was one of the papers read before the British Association which had met at Swansea on September 4. Aside from the Weisendanger paper, two additional pages in the same issue were given over to a summary of the British Association meeting, the remainder of the issue being made up of abstracts of papers presented at the Boston meeting of the AAAS.

Michels' defensive reply to Edison on October 6 (Fig. 1) was filed by Edison with a notation of *no answer*.

The Mr. Moses referred to was Otto Moses, one of Edison's engineers, who had furnished several columns of abstracts from physical and engineering literature in earlier issues of *Science*. These are signed either Otto Moses or O.A.M. None was printed after the issue of August 28.

Michels had been in touch with other institutions and laboratories aside from Menlo Park during all of this period. The second issue of *Science*, dated July 10, devoted approximately half a column to a plea from Spencer F. Baird, then secretary of the Smithsonian Institution, for information about James Smithson. The plea outlined what little was known of Smithson's life at that time and requested owners of letters from Smithson and his associates to contact Prof. Baird at the Smithsonian.

On October 13 Michels wrote that he had the day before seen Prof. Baird in New York and taken up with him a weekly report from the Institution. He reported to Edison that Baird was waiting to see how stable the journal was going to be. Although occasional reports from the Smithsonian Institution appeared in the later numbers, apparently the weekly report never materialized. Prof. Baird was to "consult with his chief clerk and endeavor to come to some arrangement." It was probably here that the arrangement broke down. As a matter of fact, the next paragraph in the letter of October 13 reveals a difficulty which has faced editors everywhere:

Mr. LeDuc also said he would do the same with the Agricultural Dept. if someone would call every week and collect the information and remind them.

The last paragraph of the letter of October 13 says that Michels intended to visit Washington to see members of the Smithsonian staff and other government bureaus and requests that Edison get him a pass on the railroad for the purpose. Apparently Edison never did this, because in the accounts of a few weeks later there is a modest item for a railroad ticket from New York to Washington and return.

During this period the expenses of the operation had been slowly mounting so that they now ran about $135 a week; the subscriptions to the journal had not come up to expectations, and it had not been sold on "every newsstand in the United States" or on any newsstand, so far as the accounts show. A significant letter dated January 26, 1881 appears in the files. Addressed to J. Michels, it says:

In regard to *Science* Mr. Edison thinks that there is not sufficient progress to warrant of an ultimate success—please write me your views in this matter so as I can show Mr. Edison. It is now nearly a year since it began and should show larger receipts he thinks than have been—probably it would be better to run out and see him and then you can talk more understandingly in the matter—this is merely a suggestion of mine as I think you could do better than in writing to him.

Very truly
Wm Carman

This letter was answered by Michels on February 10 but could not be located in the files. On February 12 William Carman again wrote Michels as follows:

Yours of the tenth received by Mr. Edison who has requested me to say that if you can get any party to take hold and put money in science you are at perfect liberty to do so. he is to [*sic*] busy to give it any attention.

Very truly
Wm Carman

At this time Edison was planning the Pearl Street station in New York, was training electricians to wire

Oct 6-1880
J. Michels

Address of Communication,
P.O. Box 3838,
New York.

"SCIENCE."

No. 229 BROADWAY, (Room 58).

New York Oct 6th 1880

To T. A. Edison Esq
Menlo Park N.J.

Dear Sir,

I was certainly not aware of the reputation you accord to Wiesendanger. I treated it as paper read before the British Association at its last meeting, and republished by the English Journals, and as such worth reproduction. In such a case I do not see that the Journal is answerable for his views, and it is open for any reader to expose his errors in a future number.—

Just now the Journal is well advised on all subjects except Physics, the chief assistant of Professor Barker called about three weeks ago and offered to help me in any way, but Mr Moses having kindly undertaken that department, and was then sending valuable matter, I declined his help.— Since then Mr Moses has suddenly stopt his communications, and not having answered a polite letter of mine to him, expressing my regret and trusting he would continue his contributions which I considered of great use to the Journal, I naturally thought he had no time to attend to the matter, or was tiffed on some point.— I was submitting all new papers on Physics to him, and should have done

Address of Communication,
P.O. Box 3838,
New York.

"SCIENCE."

No. 229 BROADWAY, (Room 58).

New York ... 188

so with Wiesendangers.— I would like to know if Mr Moses is still advising the Journal on these points, and will forward papers on Physics to him as before if such is the case.

The Journal appears to give satisfaction to the Public, as I am receiving very satisfactory letters from professional scientific men, and am adding to the permanent annual subscribers and making up a good list, so far this week five have been added—

I am about to get a man to attend to the pushing the circulation, but the difficulty of obtaining the right sort of man without paying a heavy salary is very great. I am however about to send out a shower of sample copies.—

The Popular Science Monthly published Bell's paper without drawings, three weeks after ours,— and the American Journal of Science is equally late; and has in the last issue published a part of Abney's address, published in full in "Science" Sept 12.— They will complete it in November.— If Mr Moses is still with you and can send by return a criticism on Wiesendangers papers it will be in time for this week.—

Yours Truly

John Michels.—

FIG. 1. A letter from John Michels to Thomas Edison defending the editorial policy of *Science*, October 6, 1880.

houses, and had the thousand and one details of the installation of the first electric lighting system on his hands, and on January 31 opened a New York office at 65 Fifth Avenue. Shortly after, Michels was instructed to send his weekly accounts to the new city office which, after March 1, 1881, was in charge of the young Samuel Insull, who had by that time arrived from London to become Edison's New York secretary and office manager. After this time the correspondence is completely between Insull and Michels. It was during this period that the lease on the office space at 229 Broadway ran out, and when the rent was increased $5.00 a month, Michels requested space in the Fifth Avenue Edison office, saying that he could find no suitable office space for less than $300 a year. Edison told him, however, that there was not room to take on the *Science* operation at the Fifth Avenue address, so a room was ultimately secured in the Tribune Building, this time without a lease.

Edison had expressed some annoyance at the lack of income to *Science*, so, beginning June 11 and continuing to September 24, Robert Johnson was hired at $25 a week as business manager to sell advertising space. The accounts show that Mr. Johnson's activities brought in $50 during the period.

In 1881 the 30th meeting of the AAAS was held in Cincinnati, from August 17 to 23. Michels attended the meeting, printed in the issue of August 27 a complete list of the 182 papers read, and devoted about one-third of the issue to a paper on "The Great Primordial Force," by Henry Raymond Rogers, of Dunkirk, New York. In the following issues for the remainder of 1881 frequent use was made of the papers presented at the Association's meeting. Among the features of the Cincinnati meeting in 1881 was an apparatus exhibit at which Beck, Bausch & Lomb, Bullock, Queen and Company, and Gundlach exhibited instruments. Thus, apparatus exhibits seem to have been one of the early attractions of the annual AAAS meetings, although they did not become an official part of the program until 1925. In 1881 the exhibits were held over for the meeting of the Ohio Mechanics Association, which was scheduled several days after the AAAS meeting.

Bell did not attend the Cincinnati meeting, but Michels must have written to him in Cambridge about this time because the Edison file contains the following letter, addressed to Saml. Insull and dated August 27:

> I placed the Journal before more than a thousand persons at Cincinnati and received the highest encouragement from all quarters.
>
> Professor Alex. Graham Bell has just sent me a very handsome(ly) letter expressing his high appreciation of "Science" and stating his belief that it will take the place of "Nature." He says he will be glad to enter into any plan for its advancement by giving it his personal help and attention, if I will state my plans and state what he can do.
>
> Bell states he wishes "Science" to be on a strong basis, and presently when people return I think we can arrange it so.

On October 25 a letter was directed to John Michels and signed by Thomas A. Edison personally. This letter says:

> I hereby give you notice that I will at the expiration of sixty (60) days from this date stop the further publication of "Science" if in my opinion there has not been in the meantime a great improvement in the valuation of the property.
>
> Unless you receive further notice from me you will please prepare to close up your accounts on that date when I will dispense with the further services of yourself and your staff.
>
> Yours truly,
> Thos A Edison

This letter was enclosed with another from Samuel Insull and a check for $329.14 (two weeks) covering the accounts to October 15. The Insull letter says in part:

> I also enclose you notice from Mr. Edison as to closing up the publication of Science.
>
> Mr. Edison feels that it is a very poor investment, see[s] no prospect of a return and therefore thinks it advisable to close the matter up before incurring a much greater loss.
>
> Yours truly,
> Saml Insull

On November 28 Michels wrote to Samuel Insull as follows:

> I received your report of Mr. Edison's decision with much regret, but as you state it is final. I will [do] my best to carry out his wishes in the most effective manner.
>
> Of course it is very difficult to get anybody to take the matter up at such a time and under the circumstances, but I shall make the attempt as it would save all explanations and settlements with subscribers, rent of offices, & ec. and prevent the reproach of the publication being a fiasco.
>
> The volume will be completed on the 31st of December. If I can get any one to take the matter up in the future on January 1st and assume all responsibilities from that date, will Mr. Edison authorize me to say that he will turn over all his interests on their doing so. I have only a month to make all arrangements so please let me know at once, as I cannot approach any one without making a proposition and this seems the only one I can make under the circumstances. There is some office furniture, back numbers of journal and electros. These would be useless to Mr. E. when the journal is stopped but would be an inducement for any one who would find capital to continue the publication.
>
> Yours truly,
> John Michels

The remainder of the correspondence relates to Edison's concern that there should be no outstanding debts after the printing of the December 31 issue. Michels assured him that all of the operations had been on a cash basis and that $100 would certainly clear up all minor bills. Michels also volunteered the information that he had approached the houses of Appleton, Harper, and

Scribner but does not detail their reaction. Mr. Shonnard is finally mentioned in the last letter as being willing to undertake the publication. Here the Edison laboratory record closes!

The issue of *Science* for December 31, 1881 contained an editorial which says in part: "Arrangements are in progress to increase the number of pages of *Science* from 12 to 16, the four extra pages being devoted to applied and practical science; in this division the most recent application of scientific principles to the arts and manufactures will find a place and novel inventions of real scientific merit will be fully described."

The issue of December 31 was Number 79. Number 80, which should have appeared on January 7, 1882, did not appear until January 14. It was still 12 pages in length and did not contain the promised description of practical discoveries and inventions. Number 81 appeared on January 21 and contained a long editorial on Standard Time, by C. A. Young, of Princeton, New Jersey, an account of the New York Academy of Science meeting on December 19, the meeting of the American Chemical Society on December 16, and that of the Microscopical Society of Illinois on December 9, together with two long reviews of Appleton books. Although there had been occasional book reviews in the magazine before this time, they had never before taken up as large a part of a single issue.

Number 82, which appeared on March 4, consisted of 12 pages, two of which were full-page maps of the Croton water shed, which presumably had been an interest of Michels for some time. Aside from the maps, three of six cuts used to illustrate an unsigned article on the contamination of the Croton water supply to New York are attributed to Michels in the legends. F. E. [R. is correct] Upton, who wrote for Volume 1, Number 1, also has in this number a theoretical paper on "Electric Conduction and Discharge."

Number 82, the last issue of the early *Science*, contains the obituary of Prof. John William Draper, professor of chemistry and physiology at New York University, who had died on January 4, 1881, at the age of 70 years; and by strange coincidence, the first issue of the new *Science*, published on February 9, 1883, and called Volume 1, Number 1, contains the obituary of Prof. Henry Draper, John Draper's son, who in the summer of 1878 organized the party that viewed the eclipse of the sun at Rawlins, Wyoming Territory, on July 29.

Thomas A. Edison and the Naval Research Laboratory

A. Hoyt Taylor, *Chief Consultant for Electronics, Naval Research Laboratory, Washington, D. C.*

ON JULY 7, 1915, SECRETARY OF THE Navy Daniels wrote to Thomas A. Edison, stating that one of the most important needs of the Navy was machinery and facilities for utilizing the natural inventive genius of Americans to meet new conditions of warfare, and that the Secretary intended to establish a department of invention and development to which all ideas and suggestions from either the service or civilian inventors could be referred for determination as to whether they contained practical suggestions for the Navy to take up and perfect. The Navy, he stated, had no present means of handling inventions received from the public except to send them to the various bureaus of the Navy, which were overcrowded with routine work and could not always give them the attention they deserved. The Secretary felt that the Naval officers on sea duty were in a position to note improvements but that they had neither the time, space, ability, nor, in many cases, the natural inventive mind needed to put ideas into definite shape. The Secretary had in mind a general plan of organizing a department for the Navy which met with the ideas of Edison as set forth in an interview by Edward Marshall and published in *The New York Times.* He therefore asked Edison if he would be willing, as a service to his country, to act as chairman of such a board.

On July 13, 1915, M. R. Hutchison, personal representative of Edison, visited the Secretary in Washington and advised him that Edison had consented to head such a board. The Secretary and his aide afterward visited West Orange and discussed the salient features of this board. The Secretary then wrote to the presidents of the 11 largest engineering societies of the United States and asked them to nominate two members each, to serve on this "Naval Advisory Board," a title which was afterward changed to "Naval Consulting Board of the United States." The original members of the Naval Consulting Board were: Thomas A. Edison and M. R. Hutchison, selected by the Secretary; L. H. Baekeland and W. R. Whitney, by the American Chemical Society; Frank J. Sprague and B. G. Lamme, by the American Institute of Electrical Engineers; R. S. Woodward and Arthur G. Webster, by the American Mathematical Society; A. M. Hunt and Alfred Craven, by the American Society of Civil Engineers; B. M. Sellers and Hudson Maxim, by the American Aeronautic Society; Thomas Robins and Peter Cooper Hewitt, by the Inventors' Guild; Howard

E. Coffin and Andrew L. Riker, by the American Society of Automotive Engineers; William L. Saunders and Benjamin B. Thayer, by the American Institute of Mining Engineers; Lawrence Addicks and Joseph W. Richards, by the American Electro-Chemical Society; W. L. R. Emmett and Spencer Miller, by the American Society of Mechanical Engineers; and Elmer A. Sperry and Henry A. Wise Wood, by the American Society of Aeronautic Engineers. D. W. Brunton, chairman of the War Committee of Technical Societies, was appointed to the Board after its formation by the Secretary of the Navy.[1]

At the organization meeting of the Board on October 7, 1915, the members saw the necessity for the construction of the Naval laboratory in order to get the best results from the work which they proposed to do along lines of science and invention, it being realized that the Navy Yards and their facilities were fully occupied with the active work of construction and with the maintenance of the Fleet as their primary function. A committee, consisting of Edison, Baekeland, Whitney, Woodward, and Coffin, was formed to make a study of the subject of a Naval laboratory.

Nearly all of the numerous recommendations made by this committee were ultimately carried out with the exception of the first one, which was that the laboratory should be located on tidewater of sufficient depth to permit a dreadnought to come to the dock. The majority of the committee was in favor of establishing the laboratory at Annapolis, but Edison made a minority report in favor of Sandy Hook. The present site on the old Bellevue Magazine Grounds on the Potomac, at the south end of the District of Columbia, was considered as a possible compromise. Edison was apparently somewhat displeased that his suggestion of locating the laboratory at Sandy Hook was not finally adopted, and, I am sorry to say, he never visited the Laboratory, although his son, Charles Edison, when he was Secretary

(Photo by courtesy Naval Research Laboratory)

Naval Consulting Board of U. S. Left to right: unidentified; L. H. Baekeland; M. R. Hutchison; Thomas A. Edison; Josephus Daniels, Secretary of Navy; and Franklin D. Roosevelt, Assistant Secretary of Navy. Other members of the group could not be positively identified.

[1] I am indebted for information on the history of the Board and its original organization to a book entitled *Naval Consulting Board of the United States*, written by Lloyd N. Scott, formerly Captain, U.S.A., and liaison officer to the Naval Consulting Board and War Committee of Technical Societies, and published by the Government Printing Office, Washington, in 1920.

of the Navy, visited the place a number of times and was always much interested in it. Many other members of the Board also visited the Laboratory from time to time, particularly Baekeland, Saunders, Robins, Whitney, and Maxim.

Subsequent administrations made little or no use of the Naval Consulting Board, and finally it was abolished. It is the opinion of many of the old-timers at the Laboratory that, had it been allowed to take a more active interest in the Laboratory during its very early history and had its advice been followed, the growth of the Laboratory would have been greatly accelerated. The Laboratory definitely owes its existence to the work of the Board and particularly to its *chairman, Thomas A. Edison, who, even as early as 1910, had recognized the necessity of a research organization within the Navy.* Congress appropriated the money for its establishment in 1916.

Science is fortunate to have been intimately connected with two great 19th-century scientist-inventors. Edison's birth on February 11 preceded by less than a month the birth of Alexander Graham Bell on March 3, 1847.

Alexander Graham Bell was vice-president and organizer of the Scince Company, which in 1883 published _Science_, first in Cambridge and later in New York City. Associated with Bell in this venture were his father-in-law, Gardiner G. Hubbard, of Washington, founder of the National Geographic Society; Daniel C. Gilman, president of Johns Hopkins and president of the Science Company; O. C. Marsh, of New Haven; and Samuel H. Scudder, of Cambridge, who was treasurer of the Company and served as editor of the magazine.

The Nature and Development of Operations Research

Charles Kittel, *Guggenheim Foundation Fellow in Physics, Massachusetts Institute of Technology*

OPERATIONS RESEARCH IS A SCIENTIFIC method for providing executive departments with a *quantitative basis for decisions.* Its object is, by the analysis of past operations, to find means of improving the execution of future operations.

The principles of operations research were developed during the war as the application of the scientific method to the broad strategical and tactical problems of warfare. Small teams of civilian scientists worked at the highest operational level in a number of major Allied commands on all aspects of military staff problems: planning, intelligence, operations, and training. Among such scientific groups were the Operations Research Group on the staff of Fleet Admiral E. J. King; the Directorate of Naval Operational Research on the Naval Staff of the British Admiralty; and the Operational Research Section of the RAF Coastal Command.

The scope and power of the operations research method has been demonstrated by five years of successful application in practice. Since the end of the war several progressive government and business activities have established operations research programs for peacetime objectives.

The specific primary purpose of operations research in the war was to discover means for making the best use of the military forces and weapons currently available. The main fields of activity have been classified as the study of weapons, the study of tactics, and the study of strategy—that is, the analysis and evaluation of the performance of existing weapons and tactics; and the determination of the cost in national resources of attaining various strategic objectives. Operations research is thus distinguished from laboratory research for military purposes, which is concerned with the continual improvement of the weapons of warfare. Furthermore, the elapsed times between the inception of a new proposal and its realization in large-scale combat are radically different for laboratory and operations research. The big "secret weapons" of the war, such as microwave radar, proximity fuses, jet propulsion, V weapons, magnetic mines, airborne rockets, and atomic bombs, were

in gestation from 2 to 10 years. The big, though little publicized, successes of operations research, such as the Bay of Biscay anti-U-boat offensive, the destruction of German blockade runners in the South Atlantic, the initiation of bombing by large numbers of aircraft, and the initiation of large convoys in the Atlantic, were in action usually within one to two months after the original idea was put forward.

Origins of Operations Research

The application of quantitative reasoning to military strategy can be traced back to the brilliant British aeronautical pioneer, F. W. Lanchester, whose death occurred in 1945. Lanchester's original papers on the relationship between victory, numerical superiority, and firepower superiority in combat appeared first in 1914–15 and are collected in his book, *Aircraft in warfare* (1916).

The most important of Lanchester's results is known as the "N^2 Law." Several significant principles are exhibited by this law, which assumes that the conditions of combat are such that all units of both forces can engage simultaneously: (a) Numerical superiority may be *relatively* more important than superiority in weapon performance; and (b) it is of the highest importance to deploy available combatant units in a *single large force* and to endeavor to *split up* the enemy force (strategic principle of concentration).

Lanchester has given an interesting discussion of Nelson's victory at the Battle of Trafalgar, showing that the latter's tactics were the optimum in the light of the N^2 Law.

The original conception of teams of scientists working at the operational level in military commands goes back to P. M. S. Blackett, professor of physics at the University of Manchester. Blackett guided the emergence of "O.R." from a small trouble-shooting party attached to the British early-warning radar chain in 1940 to the point where, in 1945, operations research men were attached to nearly every large British military command including, for example, Combined Operations, South East Asia Command, Tactical Air Force, Coastal Command, Fleet Air Arm, and the British Chiefs of Staff. Related work on broad logistic problems was carried out in the Ministries of Supply, Production, and War Transport.

Operations research was introduced into the U. S. forces through the influence of the British work as communicated largely through the reports from London by Shirley Quimby, of Columbia University. The nucleus of the first U. S. group was formed in 1942 in the Naval Ordnance Laboratory under the stimulus of Ellis Johnson, then on leave from the Carnegie Institution. This group, which dealt with mine warfare problems, was later transferred to the Navy Department; from here it directed the tremendous aircraft mining blockade of the Inland Sea of Japan in 1945. Philip M. Morse, of the Massachusetts Institute of Technology, started the Anti-Submarine Warfare Operations Research Group, which reported to both the Army and the Navy. This group was later to expand into the Operations Research Group on the staff of the Commander in Chief, U. S. Fleet. As the major American group, it dealt with submarine and anti-submarine warfare, aircraft and amphibious operations, and anti-aircraft and new weapons analysis. Its work has been described by P. M. Morse (*Tech. Rev.*) and Jacinto Steinhardt (*U. S. Nav. Inst. Proc.*, 1946, **72**, 649).

In the U. S. Army there were a considerable number of separate Operations Analysis Sections whose work was divided between the statistical analysis of operations and the nursemaiding of new weapons and equipment in the transitional stage between the laboratory and the wide-spread use of the new gear in combat.

Personnel for Operations Research

It is often asked why scientists are required for operations research work, since the actual details involved are fairly simple and apparently might be done by any college graduate without specialized training. The answer has two parts: First, a scientist is, by profession, trained to reject unsupported statements and has an instinctive desire to rest all decisions on some quantitative basis, even if the basis is only a rough estimate. This makes scientists good at detecting the existence of problems and questions of which the regular military staff may be unaware. Second, scientists, through their research experience, are trained to get down to the fundamentals of a question—to seek out broad underlying principles through a mass of sometimes conflicting and irrelevant data. They know how to handle data and how to guard against fallacious interpretations of statistics.

The particular type of mentality which is a success in operations research appears, from wartime experience, to be found most frequently in physics and biology and their associated borderline sciences; the special outlook seems to be found somewhat less commonly in mathematics, engineering, and economics, although there are some brilliant exceptions.

The actual responsibilities of operations research groups attached to high commands are usually advisory, rather than executive, in nature. The groups must have freedom to initiate studies and must have access to any information required.

Operations Research Problems

A proposed operation frequently is such that a study of its inherent capabilities reveals the basic philosophy underlying the operation and leads to the recommendation of a *single course of action*. Two important examples of this nature are given here:

(1) *Thousand-plane raids*. Statistics of the losses of RAF Bomber Command aircraft over selected German cities indi-

cated that the percentage of aircraft lost fell off as the number of aircraft participating in the raid increased, suggesting that the German defenses were being saturated. If, then, the number of aircraft is increased over the saturation limit, the number of casualties should remain constant, and the *effectiveness ratio*,

$$\frac{\text{tons of bombs on target}}{\text{own aircraft lost}},$$

should therefore increase. On the basis of this analysis the first thousand-plane raid in history was made by the RAF in 1942; the results of this and subsequent large raids confirmed the prediction.

(2) *Large merchant-vessel convoys.* A similar analysis of the losses in North Atlantic merchant-vessel convoys showed that the average number of ships sunk in a convoy was a constant, independent of the size of the convoy. It was, in fact, found that the percentage casualties, L, were given approximately by the equation,

$$L = c/SE, \tag{1}$$

where S is the number of ships in the convoy, E the number of escort vessels, and c is a constant. As a direct consequence of this analysis early in 1943 the time between convoys was lengthened so that each convoy was larger and protected by more escorts.

This decision resulted in greatly diminished losses.

In many operations it is desired to maximize the yield or productivity of the operation with respect to *several competing factors.* Two examples are:

(1) *Bombing of Japan.* Squadrons of B-29's based in the Marianas for the purpose of bombing Japan were able to put in a fairly definite number of flying hours per month, this time being distributed between operational missions and training. If no time is spent on training, it is found that the average proportion of the bomb load dropped on the target is low; if all the time is spent on training, obviously no bombs will be dropped on the targets in Japan. An analysis of the improvement in bombing accuracy with training indicated that the maximum bomb weight on the target was achieved if about 10 per cent of the flying time is spent on training and 90 per cent on operational missions; it was further shown that this distribution doubled the bomb weight on the target obtained with the original distribution of about 4 per cent training and 96 per cent operations. Training problems of this character are encountered in many situations in civilian as well as in military economy.

(2) *Submarine wolf packs.* A submarine which patrols a shipping lane independently is likely to attack only the contacts made by itself. If groups of submarines patrol a route together, each submarine can attack contacts made by its neighbors as well as by itself, thus tending to increase the productivity of a submarine war patrol. There is clearly an optimum size for such a wolf pack. An upper limit to the size would be given by the number sufficient to destroy totally any task force or merchant-vessel convoy encountered. Actually, such total annihilation was extremely rare and in general would require enormous forces. Another consideration determines the optimum: if the pack is too large, contacts which otherwise might have been made on other shipping routes are missed. The U. S. Navy used groups of three submarines in attacks on Japanese shipping.

Exchange Rates

Perhaps the most characteristic feature of the operations research methodology is the discussion of a problem in terms of *exchange rates.* The exchange rate is essentially the ratio of output to input for a given type of operation, as measured in suitable units. For example, in the early stages of the campaign against Japanese shipping it was desired to know which of the available means of attack—submarines, aircraft, and mining—could most profitably be expanded. By considering expenditures on construction, training, operations, and replacements it was possible to get values of the exchange rate,

$$\frac{\text{Japanese ships sunk}}{\text{Allied man-years of effort}},$$

for the three means of attack; the result demonstrated the profitability of U. S. submarine operations.

Similarly, the geographical distribution of flying effort by Allied aircraft in the anti-U-boat war was largely determined by the exchange rate,

$$\frac{\text{flying hours}}{\text{U-boat sightings}}.$$

In a "hot" area this ratio might be less than 100; in areas characterized by heavy overflying the ratio was as high as 25,000. The analysis indicated the value of transferring aircraft from the Gulf of Mexico to the Bay of Biscay, for example. A parallel study discussed the relative profitability of using anti-submarine aircraft to bomb the U-boat bases on the French coast, to escort threatened convoys, and to do routine patrol of shipping routes.

The British had laid down a program for building a certain number of escort-type vessels in 1943. These vessels could be equipped for minesweeping or for anti-submarine duty. A study of the exchange rate,

$$\frac{\text{merchant vessels saved}}{\text{new naval escorts built}},$$

indicated the importance of the anti-submarine escorts. A similar analysis was made of the value of the "armed guard" crews on merchant vessels.

The profitability of the RAF Bomber Command raids on German cities was analyzed in terms of the exchange rate,

$$\frac{\text{Allied man-years in bombing effort/bomb tons dropped}}{\text{enemy man-years on defenses and indispensable repairs/bomb tons dropped}},$$

thus giving an effective man power exchange rate. The rate, when broken down for different types of aircraft, showed the surprising effectiveness of the Mosquito raids

and the superiority of the Lancaster over the Halifax bomber. A parallel analysis of the situation from the enemy point of view considered the economics of bombing with the V weapons as compared with conventional bombing.

The allocation of U. S. submarines to the several submarine commands was considered in terms of the exchange rate,

$$\frac{\text{Japanese ships sunk}}{\text{submarine months at sea}}.$$

A somewhat similar analysis considered the disposition of minesweepers as between the East and West coast ports of England.

Effectiveness Ratios

The basis of the reliability of the estimated exchange rates lies in the remarkable constancy of certain effectiveness ratios involved in the operations. For example, the figure of 60 mines laid/ship sunk has been found to occur in every aircraft mining campaign—German mines in British ports, British mines on German routes, and U.S. mines on Japanese routes.

Similarly, the probability that an aircraft will attack a U-boat which has been sighted is a number which averages the same for different aircraft types and different theaters of war. In submarine operations the value of the effectiveness ratio,

$$\frac{\text{Japanese ships sunk}}{\text{torpedoes fired}},$$

was the same in Japanese coastal waters as in the South China Sea.

Blackett has pointed out that the stability of certain factors involved in operations "appears rather unexpected in view of the large number of chance events and individual personalities and abilities that are involved in even a small operation. But these differences in general average out for a large number of operations and the aggregate results are often found to remain comparatively constant. . . . It is applicable whenever operations have been in progress and tactics have been sufficiently stabilized, as they often are for months at a time, for definite experimental data on the results of past operations to be obtained. It should be remembered that the technical instruments of warfare do not change rapidly owing to the long duration of development and production. And even tactics cannot usually change very fast owing to the necessary duration of training. Thus the condition of relative stabilization of operational technique is quite often fulfilled."

The real significance of the constancy of the effectiveness ratios lies in the possibility of transplanting data from one area to another with reasonable assurance of coming out with a correct result. For example, the average number of rounds from the five-inch guns of destroyers required to break up a Japanese pillbox on Tarawa could be expected to be approximately the same as the number of five-inch rounds required to destroy a German pillbox of the same size on the Normandy coast. The value of using effectiveness ratios in the planning of force requirements and logistic support may easily be appreciated.

Peacetime Applications of Operations Research

The operations research methods and techniques have wide application to modern government and industry. Quoting Steinhardt, "These techniques are those of the competent scientist, applied to large-scale human operation as a whole, with the aim of fitting the operation to its purpose, and of measuring the effectiveness with which the operation is carried out."

The British have been thoroughly convinced of the value of this type of research and are developing a number of peacetime applications to civil life. There are plans for conducting operations research in civil aviation (British Overseas Aircraft Corporation), housing (Ministry of Works, under J. D. Bernal), steel industry (British Iron and Steel Institute, under Sir Charles Goodeve), and commerce (Board of Trade, under T. Easterfield). These enterprises, because of their national character and size, lend themselves more suitably to the application of operations research than do small local enterprises. There have also been several economic advisers in the Cabinet Offices and in the former Ministry of Production who approach broad national problems using quantitative criteria and measures of effectiveness.

The accomplishments discussed include only a few selections from a great collective effort. It is impossible to mention or to give adequate credit to all of those who shared in the work. Tribute must be paid, however, to P.M.S. Blackett, F.R.S., the dean of operations researchers everywhere; and I wish to add my personal thanks to him for the privilege of spending many months of the war with his group in the Admiralty. I wish also to express my appreciation to P.M. Morse and H.R. Hulme for many stimulating discussions of the methods of operations research.

It is hoped that the publication of this paper will serve to stimulate the establishment of operations research groups in the United States for the advancement of peaceful objectives. This powerful new tool should find a place in government and industry.

Patent Policies in Educational Institutions and Nonprofit Research Organizations

Archie M. Palmer
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THE REVIVAL AND ACCELERATION OF research activities in universities and other research centers, following the return of scientific men to the campus and laboratory on release from wartime responsibilities and occupations, promise a rich period of productive research, especially in areas neglected or subordinated during the war, even though heavy teaching loads resulting from swollen postwar enrollments in the universities may slow down production temporarily and in certain areas.

Of increasing importance to administrators and scientists engaged in these research activities is the policy or procedure to be followed in handling any patentable ideas or devices that may be discovered during the course of the investigations. At present there is a wide diversity of practice among educational institutions and research organizations in their methods of dealing with inventions growing out of scientific research. However, there is a growing tendency to adopt definitive patent policies and to establish machinery to meet situations which have arisen or are anticipated.

The National Research Council is currently making a comprehensive factual survey of existing policies, procedures, and practices followed in the administration of patentable results of scientific research in educational institutions and nonprofit organizations, with a view to early publication of the findings.

The survey is being conducted under the sponsorship of the Council's Committee on Patent Policy, of which Frederic W. Willard is chairman. The other members of the Committee are: Bruce K. Brown, Conway Coe, Gano Dunn, Edward S. Mason, Archie M. Palmer, Lewis H. Weed, William Charles White, and, ex officio, Detlev W. Bronk, chairman of the Council. The survey is being made under the direction of the writer, assisted by Hugh Samson.

Through correspondence, conversations and personal visits, the director of the survey is endeavoring to assemble all available information concerning existing practices and present thinking about patent management matters in administrative and scientific circles. Despite the importance of the problems involved, comparatively little material of current value is available in the scientific and technological literature.

The desired data are being sought through direct requests to the institutions concerned, and most of the usable material has been coming in as a result of those requests. Some of the information is contained in bulletins, reports, and other publications issued by colleges, universities, professional and technological schools, agricultural and engineering stations, government agencies, and nonprofit research organizations.

Information available in this form has usually related to the more definitive policies. At many institutions practices or procedures currently being followed are not yet clearly formulated in definitive policy statements. In a number of the institutions where definitive patent policies have been adopted, those policies are now under review to meet changing postwar conditions.

In order to obtain firsthand information and to observe the programs in action, the director is making a series of trips to the more important research centers where significant policy programs are in operation. The information gained, views exchanged, and situations clarified, as well as the personal observations made, have led to better understanding and more accurate interpretation of the practices of the institutions visited.

The success of the survey, its value to administrators of research activities and to research workers, and the significance of the findings will depend to a great extent upon the cooperation and assistance of persons in educational institutions and research organizations who have had experience with patent problems and are willing to share those experiences.

A report, to be published in May or June 1947, will present a factual account of the situation as it exists today. All specific references to institutional policies or procedures will be submitted to the institutions for approval prior to publication in the final report. Similarly, statements of experiences with patent problems and expressions of attitudes toward the operation of patent management policies will be submitted for approval to the individuals responsible for them.

In addition to definitive statements of significant patent policies and practices currently in operation in educational institutions and nonprofit research organizations, analyses will be made of the various types of policies and of the considerations underlying their formulation. In so far as the information is made available by those concerned, reasons for the establishment of patent policies and the specific instances which led to the adoption of particular policies will be included in the report. Account will also be taken of the changes in patent

philosophy and management procedure brought about by the intensive and far-reaching wartime research programs conducted at many institutions.

Administrative procedures for screening patentable results of scientific research, for prosecuting the patent application, for protecting patents against infringement, and for promoting, licensing, and assigning patents will also be analyzed. This will include study of the objectives and operation of committees and other agencies set up to deal with these aspects of the problem.

Questions relating to the equity of the inventor, of the institution, and of the sponsor or supporter of the research, where there is such a third party or outside agency involved, will also be considered. There is apparent a lack of uniformity in the approach to these questions, and the wide diversity of practice indicates a need for intensive study of the factors underlying the decisions made in specific cases. The increase in cooperative and sponsored research in educational institutions accentuates the need for such a study.

One of the most important and controversial aspects of the patent problems—what to do about patents affecting public health—will be reviewed to ascertain whether and where separate or special policies are in existence with reference to medical and pharmaceutical inventions and discoveries. How such matters are administered and how the public interest is protected will be given special consideration.

Other items of concern to research workers and faculty members generally, which will be included in the survey, relate to restrictions on publication and other disclosures of research findings, contractual arrangements made with research workers and with the sponsors of the research, and the distribution of the proceeds from royalties and disposal of the patents. These and other aspects of the whole patent problem will be studied with respect to their relation to the different types of research —fundamental, experimental, and developmental.

The development of special research foundations and similar agencies, both independent and with institutional affiliations, for the administration of patents as well as the conduct and direction of sponsored research programs will be given full treatment in the survey. Analyses will be made of their organization, objectives, financing, research and administrative programs, and relations to educational institutions.

Of greatest value in the interpretation and presentation of the factual information will be the experiences of the institutions in their handling of patent problems and the attitudes and reactions of the research workers. The director of the survey will welcome full and frank discussions of these matters, through correspondence and in conversations during his visits to the various research centers.

NEWS *and Notes*

More than 100 representatives of national scientific and educational societies have been appointed to membership in the Inter-Society Committee on Science Foundation Legislation, pursuant to action taken by the Council of the AAAS on December 29, 1946 (*Science*, January 3, p. 7, and January 31, p. 117).

There are yet many organizations whose presidents should have received President Conant's letter of January 4, 1947, but which have not yet responded to the request to designate representatives to the new Committee.

As announced last week in *Science*, the first meeting of the Inter-Society representatives, at which the Committee will be organized, is scheduled for 10:00 A.M., Sunday, February 23, at the Hotel 2400, 2400 16th Street, N.W., Washington, D. C. The meeting will adjourn at noon for luncheon, at which the members of the Committee will be the guests of Science Service, and will then be resumed for an afternoon and, if necessary, an evening session.

It is imperative that each designated representative on this Committee make every effort to be present at this initial meeting. It is expected that officers will then be selected, together with a small executive committee, and that much attention will be given to the procedures and strategy to be followed in the next few months.

Notices of the meeting are being sent to all whose names have been submitted to the Executive Offices of the AAAS, but Prof. Mather, who is chairman of the AAAS Council Committee arranging the organization of the new Inter-Society Committee, calls attention to the fact that changes in administrative personnel among many scientific and educational societies have presumably delayed the selection and reporting of their official representatives. He suggests that this announcement in *Science* be taken as a sufficient invitation to interested persons to attend the meeting. In fact, anyone actively concerned with the plans for a National Science Foundation, and who has not been designated as the official representative of one of the societies affiliated with the AAAS or of the small number of other national organizations named by the Council of the AAAS, will be welcome to be present "with voice but without vote." Prof. Mather would like to

hear from any such persons in advance of the meeting. He should be addressed at Harvard University, Cambridge, Massachusetts.

About People

Oscar E. Meinzer, who retired as chief, Ground Water Division, U. S. Geological Survey, late last year, has been succeeded by A. Nelson Sayre. Dr. Sayre, with the Survey since 1929, has supervised ground water investigations in several states. During the war he reported on water supplies of enemy-held areas in Africa, Europe, and the Pacific region, and made special investigations in Central America and the Philippines for which he was awarded the Medal of Freedom.

Dr. Meinzer retired November 30 after more than 40 years of service in the Geological Survey and 34 years as chief of the Ground Water Division.

Erwin C. Stumm has been appointed associate curator of Paleozoic Invertebrates, Museum of Paleontology, and assistant professor, Department of Geology, University of Michigan, effective July 1.

Homer D. Holler has been appointed to the staff of the National Bureau of Standards to work with I. A. Denison, of the Underground Corrosion Section. Dr. Holler joins the Bureau staff from Westinghouse Electric Corporation, where he has been responsible for corrosion investigation and control since 1929. He had been with the Bureau of Standards between 1915 and 1919 and from 1925 to 1929. The problem of deterioration of underground metallic structions, which the Bureau has studied for many years, has become critical with the sharp increase in the miles of underground gas, oil, and water pipelines, it has been shown, and estimated losses due to such corrosion amount to $100,000,000 annually.

Hans Lowenbach, associate professor of neuropsychiatry, Duke University Hospital and School of Medicine, resumed his work at Duke recently following a six-month assignment in Germany in which he gathered manuscripts on medical and related research which had remained unpublished due to wartime conditions. More than 25,000 pages of original manuscripts on general pathology, neuropsychiatry, and high-altitude studies were collected and microfilmed. Most of the papers concerned research held secret under German wartime restriction. They are now being abstracted and will be available immediately through the office of the Publications Boards, Department of Commerce, 16th and K Street, N.W., Washington 25, D. C.

Marston Taylor Bogert, emeritus professor of organic chemistry, Columbia University, as president of the International Union of Chemistry, has been invited by the Chemical Society, England, to be one of its guests during centenary celebrations, July 15–17, in London.

C. H. Cleminshaw has been made associate director of the Griffith Observatory, Los Angeles, California, in recognition of more than four years service as acting director during the absence of the director on war service.

Seymour J. Gray has been appointed assistant professor of medicine, Harvard University Medical School, and senior associate in medicine, Peter Bent Brigham Hospital. Dr. Gray, who formerly was assistant professor of medicine, University of Chicago, and later Lt. Cdr. in the U. S. Naval Reserve, will divide his time between duties as director, Gastro-Intestinal Clinic of the Hospital, and as member of the Medical School group conducting research in biophysics.

Donald G. Marquis, professor and chairman of the Department of Psychology, University of Michigan, and president-elect, American Psychological Association, has been granted a half-time leave of absence from January 1 to the end of the current academic year to direct a study in social sciences for the Carnegie Corporation.

Visitors to U. S.

James Yu Ping Chen, graduate of Peking Union Medical College, who spent the past year as research fellow in pharmacology, University of California Medical School, San Francisco, has accepted a research fellowship in chemotherapy under Ralph G. Smith and Ernest C. Faust, Tulane University School of Medicine, New Orleans.

Sir Edward Mellanby, secretary of the Medical Research Council, London, is to be Flexner Lecturer at Vanderbilt University School of Medicine during March and April 1947. He will deliver five lectures on the subject, "The Experimental Method in Problems of Nutrition."

Norbert Goormaghtigh, professor of pathology, University of Ghent, will spend April and May in the United States. Invited by the Belgian-American Educational Foundation, Inc., Prof. Goormaghtigh will lecture at universities and medical schools in many cities and will attend meetings of the American Pathology Societies in Chicago in May.

Grants and Awards

The University of Missouri, for the third consecutive year, has awarded eight research professorships to faculty members for the summer of 1947. The appointments allow full time for research during the summer session, on the campus or elsewhere. Following are scientists who received research grants: Daniel Mazia, associate professor of zoology; Lloyd E. Thomas, associate professor of biochemistry; and Melvin H. Marx, assistant professor of psychology.

Calvin P. Stone, professor of psychology, Stanford University, California, has been awarded $2,400 for research in electroconvulsive shock therapy by the Committee for Research of the Scottish Rite Fund, New York. Dr. Stone, who has studied the effects of shock treatment on memory and other faculties of human patients, in the present research will study its effects on rats which have been determined to be excellent subjects for such experiments in earlier work. The effects of shock therapy on the mental faculties of rats, on their emotions, their energy, and the conative functions, will be studied.

The New York Academy of Medicine has announced availability of the Louis Livingston Seaman Fund for research in bacteriology and sanitary science. Applications for grants from $2,500 available for assignment in 1947 should be addressed to Wilson G. Smillie, Chairman, Louis Livingston Seaman Fund, 1300 York Avenue, New York 21, New York, before March 1.

Northwestern University and the Carnation Company have established a fellowship at the University for investigating the chemical nature of Tenulin, the bitter principle of *Helenium tenuifolium* that causes a large waste of milk in the southern states. Richard

Merner, formerly of the Du Pont Company, is first recipient of the fellowship.

Duke University announces availability of the Charles W. Hargitt Annual Research Fellowship in Zoology. Inquiries about the fellowship, primarily for postdoctoral research in cytology and carrying a stipend of $2,000, should be sent to C. G. Bookhout, Biology Building, Duke University, Durham, North Carolina.

H. A. Spoehr, director of the Stanford Laboratory of the Carnegie Institution, has been elected a life member of the California Academy of Sciences.

The New York Academy of Medicine announces that a sum of $1,500 is available during 1947 under the Edward N. Gibbs Memorial Prize for original research on causation, pathology, and new methods of treating diseases of the kidney. Candidates must be physicians who have been graduated at least three years and are residents of the United States. Applications should be addressed to The Gibbs Prize Committee, New York Academy of Medicine, 2 East 103rd Street, New York 29, New York, before March 31.

Colleges and Universities

Case School of Applied Science, Cleveland, Ohio, and the General Electric Company will offer 50 fellowships to high school teachers of physics for a six-week program of study during the summer of 1947. The fellowships, designed to acquaint teachers with recent scientific developments, include all fees, room and board, and travel expenses. High school and preparatory school teachers of physics from the following states are eligible to apply: Ohio, Michigan, western Pennsylvania, West Virginia, Kentucky, Indiana, Illinois, Wisconsin, and Maryland. Applications should be sent to Elmer Hutchisson, dean, Graduate Division, Case School of Applied Science, Cleveland 6, Ohio.

Northwestern University has on exhibit in the Chicago Museum of Science and Industry through February 9 a new electron microscope purchased for use in the Technological Institute on the Evanston campus. The instrument, which employs a beam of electrons for magnification instead of light, resolves 1/10,000,000 inch accurately, compared with 1/100,000 inch with the ordinary light microscope.

Olivet College, Michigan, will offer for the first time this spring an annual prize of $50 for the outstanding scientific paper written by one of its students. The prize honors Hubert Lyman Clark, professor of biology at Olivet from 1899 to 1905, and until recently curator of Marine Invertebrates, Museum of Comparative Zoology, Harvard University.

The University of Nebraska College of Medicine will continue work in muscle physiology under A. R. McIntyre, chairman, Department of Physiology and Pharmacology, under a grant of $11,980 by the National Foundation for Infantile Paralysis.

The Yale University School of Forestry will apply methods used by the Air Forces for analyzing aerial photographs to the problem of surveying timberlands, under a project conducted by Walter H. Meyer and Eugene V. Zumwalt. The purpose of the project is to develop new methods of estimating the volume of timber in tracts of land, an operation now performed mainly by skilled estimators who walk through the forest and calculate the kind, quality, and amount of timber.

Photographs of woodlands near New Haven will be made by a commercial flying company supplying materials for the study, at different times of the year, at different heights, and with varying photographic filters. Yale investigators then will study results with special measuring devices and stereoscopic optical equipment, which permit measurement of the height of individual trees and width of their foliage, regardless of the altitude from which the photographs are taken.

Aerial surveys, according to Profs. Meyer and Zumwalt, can also be used for constructing accurate contour maps of the areas to be cut over, which help in locating swamplands and planning and laying roads for the timber operations.

New infrared photographic techniques developed by the Army and Navy will be used. The whole aim of the different photographic techniques, it was said, is to develop textures and shadings in photographs which would be useful in determining the density of tree growth and possibly the kind of trees.

The University of Copenhagen on December 14 celebrated the 400th anniversary of the birth of the Danish astronomer, Tycho Brahe. On the occasion the rector of the University, Prof. Nørregaard, anounced plans for constructing a new observatory under the direction of Bengt Strömgren, financed by the government with the assistance of the Carlsberg Foundation and the Danish Academy of Sciences.

At the same celebration the University awarded honorary doctors' degrees to 11 astronomers and 1 university administrator: Sir Harold Spencer Jones, Astronomer Royal of England; F. J. M. Stratton, director, Solar Physics Observatory, Cambridge, England; A. Danjou, director, Paris Observatory; J. H. Oort, director, Leiden Observatory; B. Lindblad, director, Stockholm Observatory; E. Hertzsprung, director emeritus, Leiden Observatory; Otto Struve, director, Yerkes and McDonald Observatories; S. Rosseland, director, Oslo Observatory; G. A. Shajn, director, Crimean Astrophysical Observatory, U.S.S.R.; A. A. Mikhailov, chairman, Astronomical Council of the Soviet Academy of Sciences; Harlow Shapley, director, Harvard College Observatory; and Robert M. Hutchins, chancellor, University of Chicago. The last five degrees were awarded in absentia.

Industrial Laboratories

General Electric Company has developed an automatic flight recorder, designed to provide recorded data which will help determine the cause of aircraft accidents. The new instrument also provides easily read records of a plane's altitude, vertical acceleration, air speed, compass-heading, and any other operational data which can be measured with standard aircraft instruments. Any standard aircraft instruments of the pointer-indicating type can be used with the new recorder, General Electric engineers pointed out.

Tiny electric transmitter signaling devices, known as selsyns, are installed on the standard aircraft instruments. Each selsyn transmits the position of its instrument's pointer to a receiver selsyn in the flight recorder, which is geared to the inkless recording system. The recorded trace is about .02 inch in width. Quality of the trace is not affected by altitude or temperature, and records can be submerged in salt water for several days without damage.

The aircraft instruments can be installed in any part of the plane where desired data can most easily and accurately be measured, it was explained, while the flight recorder can be installed in the aircraft tail for possible crash protection.

A 24-page booklet describing methods for increasing the effective sensitivity of black-and-white photographic emulsions has been prepared by members of the Kodak Research Laboratories and is available on request from Industrial Photographic Division, 343 State Street, Rochester 4, New York. The booklet is a reprint of "Methods of increasing film speed," an article in the November, 1946, *Photographic Society of America Journal.*

The Miner Laboratories, Chicago, Illinois, announce establishment of a new Entomological Division under the direction of Barbara Miner Parker, a staff member of the Laboratories for several years. The Division will be especially equipped to handle research on stored cereal products, but will do other types of work not requiring greenhouse or field facilities.

A method for reducing errors caused by scattered radiation in photographic X-ray absorption measurements which are useful in calibrating X-ray machines and analyzing X-radiation has been developed by H. E. Seemann and L. L. MacGillivray, of Kodak Research Laboratories.

Absorption curves are normally obtained by observing ionization chamber or Geiger counter indications of X-ray intensity for different filter thicknesses in the X-ray beam. Filters are placed near the X-ray tube so scattered X-rays will not be included in the measured beam, but the arrangement requires many observations. Usually attempts to record X-ray absorption data photographically with a single exposure involve the use of a "stairs" of different thickness filter material placed directly on the film holder.

The Kodak researchers found that errors could be reduced by irradiating only a minimum amount of matter, placing the absorbing material some distance from the film, and keeping the different filter elements separated by lead partitions so that scattering cannot spread indefinitely.

To meet these conditions, a lead chamber made up of several parallel longitudinal compartments was used. Filters of different thickness were placed over holes in the end where the X-rays enter, and recording films were located at the exit end. Experimental results show that, in a particular design, 97 per cent of the scattering is eliminated. Furthermore, all filters are exposed simultaneously, promoting accuracy in relative absorption measurements, particularly when short exposure times only are possible.

Meetings

The American Society of Mechanical Engineers will hold its spring meeting March 2–5 at the Mayo Hotel, Tulsa, Oklahoma. With "The Industrial Development of the Southwest" as its theme, some 20 technical papers will be read on power, aviation, management, fuels, industrial instruments and regulators, oil and gas power, education, petroleum, and metals engineering. A registration of 400–500 is expected.

The Society of American Bacteriologists will hold its annual meeting in Philadelphia May 12–16, with headquarters at the Bellevue-Stratford Hotel. There will be sessions on general, agricultural, industrial, and medical bacteriology, as well as immunology and comparative pathology.

The Institute of Navigation will hold its eastern regional meeting February 13–14 at the Hotel Pennsylvania, New York City. Seventeen papers will be read at the meeting, which will be open to nonmembers as well as members of the Institute.

The American Society for Engineering Education will hold its 55th annual meeting June 18–21 at the University of Minnesota, Minneapolis.

Elections

The American Society of Naturalists, meeting in Boston December 31, elected K. S. Lashley, Yerkes Laboratories of Primate Biology, Orange Park, Florida, president for 1947; M. Demerec, Columbia University, vice-president; and Wilson S. Stone, University of Texas, secretary. The treasurer, T. M. Sonneborn, continues in office.

Z. P. Metcalf, associate dean, Graduate School, and head, Department of Zoology and Entomology, North Carolina State College, has been elected president of the Entomological Society of America.

The Botanical Society of America, Inc., has elected the following officers for 1947: R. E. Cleland, University of Indiana, president; Edgar Anderson, Missouri Botanical Garden, vice-president; T. G. Yunker, DePauw University, treasurer; John S. Karling, Columbia University, secretary; and A. J. Eames, Cornell University, member of Editorial Board of the *American Journal of Botany.*

The American Society of Photogrammetry, at its annual meeting in Washington January 22–24, elected the following officers for 1947: Revere G. Sanders, Fairchild Camera and Instrument Corporation, Jamaica, New York, president; E. S. Massie, U. S. Forest Service, first vice-president; Russell K. Bean, head, photogrammetric unit, Geological Survey, second vice-president. According to custom, Mr. Massie will succeed to the presidency a year from now. J. M. Haynie, Lt. Cdr., USN (retired), was elected business manager of the Society and editor of *Photogrammetric Engineering,* with offices in Washington.

The Association of American Geographers elected the following officers at its 43rd annual meeting at Ohio State University December 28–30: Charles F. Brooks, Harvard University, president; Clarence F. Jones, Northwestern University, vice-president; George B. Cressey, Syracuse University, councilor for three years; Guy-Harold Smith, Ohio State, treasurer; and Chauncy D. Harris, University of Chicago, secretary.

The Association met with the American Society for Professional Geographers and the National Council of Geography Teachers. Total attendance was 480.

The Anthropological Society of Washington, at its annual meeting January 21, elected for 1947, Regina Flannery, Catholic University of America, president; William N. Fenton, Bureau of American Ethnology, vice-president; Marshall T. Newman, U. S. National Museum, secretary; John C. Ewers,

U. S. National Museum, treasurer; and W. M. Cobb, Howard University, W. H. Gilbert, Jr., Library of Congress, Ruth E. Pardee, UNRRA, D. B. Shimkin, U. S. Army War College, and Gordon R. Willey, Smithsonian Institution, councilors to serve on the Board of Managers.

The **Chicago Natural History Museum's** zoological expedition in the Philippines, headed by Harry Hoogstraal, reports it has obtained large collections of mammals, birds, reptiles, and insects. The group, whose work will continue into the summer of 1947, is in Davao Province at a camp 7,200 feet above sea level in the cloud zone on Mt. McKinley, and is planning a survey of Mt. Apo.

During the AAAS meetings, a committee to aid foreign bryologists was established by the Sullivant Moss Society. Members include E. B. Bartram, I. M. Haring, G. Sayre, A. J. Sharp, W. C. Steere, F. Verdoorn, and R. T. Wareham. On behalf of the committee Drs. Steere and Verdoorn are communicating with European colleagues to inquire about the help most needed. G. Sayre is drawing up a list of the assistance available from members of the Sullivant Moss Society who plan to help European colleagues with literature, specimens, laboratory supplies, food and clothing, and miscellaneous small items.

The textile gallery of the Science Museum, South Kensington, England, closed during the war, was reopened to the public January 4. Before the war this gallery was one of the most popular, particularly among students, providing a wide view of techniques used in branches of the textile industry.

The U.S.S.R. has the most foreign subscriptions and England the second largest number to American technical journals in the field of physics, an analysis of subscriptions to the eight journals published by the American Institute of Physics indicates. Foreign subscriptions from 59 countries are at an all-time high, the analysis, published in the current *Review of Scientific Instruments*, shows, and represent 23 per cent of all subscriptions. Foreign scientists also report their research in American publications. The Institute in 1939 published 122 papers from England, 82 from Canada, and 46 from the U.S.S.R.

In the sixth annual Science Talent Search conducted for Westinghouse Science Scholarships by Science Clubs of America, Science Service, 300 1947 high school seniors believed to have unusual potential scientific ability have been awarded honors.

Nine girls and 31 boys picked from 16,558 contestants are being invited to Washington, D. C., for an all-expense trip February 28 to March 4 to attend the Science Talent Institute. There, one boy and one girl will be awarded the $2,400 Westinghouse Grand Science Scholarships. Eight winners will be awarded $400 scholarships, and $3,000 in scholarships will be awarded at the discretion of the judges.

A research program to discover minor planets and study those already observed has been set up by the American section, International Astronomical Union, in charge of Paul Herget, director, University of Cincinnati observatory. Cooperating observatories will be Yerkes, University of Chicago; Lick, University of California; Warner and Swasey, Case School of Applied Science; Harvard, Harvard University; Dearborn, Northwestern University; Kirkwood, Indiana University; and Naval Observatory, Washington, D. C.

According to Dr. Herget, 1,500 minor planets, all moving around the sun, are now known. The first, 500 miles in diameter, was discovered in 1801; others are considerably smaller. Most minor planets, however, have been discovered in recent years when astronomers could make use of photographic plates, and before the war new ones were being identified at the rate of 100 a year.

The Smithsonian Institution has elected Fred M. Vinson, Chief Justice of the Supreme Court, chancellor of the Institution to succeed the late Chief Justice, Harlan F. Stone. In 1946, the centennial year, the number of specimens received by the Institution and the number of visitors showed an increase, with the latter exceeding 2,000,000, Alexander Wetmore, secretary, stated.

Recent Deaths

Morris Raphael Cohen, 66, professor of philosophy at the University of Chicago until his retirement in 1941, died January 28 at his home in Washington, D. C. Dr. Cohen, one-time president of the American Philosophy Association, was author of several books, among them *introduction to logic and scientific methods*, which he wrote in collaboration with Ernest Nagel.

Howard Shreve Roberts, 56 physicist at the Carnegie Institution of Washington, died in Presbyterian Hospital, New York, January 30. With the Carnegie Institution geophysical laboratory since 1917, he assisted the laboratory's investigation of ordnance matters under OSRD during World War II. He was known for work on design of electrical apparatus, crystal structure determination by X-ray, and measurement of thermal properties of minerals and rocks.

Ralph R. Beal, 59, vice-president in charge of engineering of RCA Communications, Inc., New York, died of a heart attack in New York January 24. During the war Mr. Beal was a member of the Microwave Committee of OSRD.

George T. Caldwell, 65, professor and chairman, Department of Pathology, Southwestern Medical College, Dallas, died January 20.

Charles Albert Browne, chemist with the U. S. Department of Agriculture until his retirement recently, died on February 3 in Washington.

NRC News

A study of the personnel qualifications and directory information which exists on highly trained personnel of the natural sciences, social sciences, humanities, and education has recently been undertaken by the Office of Scientific Personnel of the National Research Council.

The project is sponsored jointly by the National Research Council, the Social Science Research Council, the American Council of Learned Societies, and the American Council on Education. Lowell H. Hattery has been retained as research consultant to carry out the study. He is now describing and evaluating the personnel information on file in government bureaus, professional societies, and other sources.

It is hoped that the survey of existing information and an analysis of future plans may give some indication of the desirable and practical methods for documentation of individual personnel information on the Nation's professional personnel resources.

COMMENTS

by Reader's

Pennsylvania State College is to be congratulated for establishing a Laboratory of Applied Geophysics and Geochemistry (**Science,** November 1, 1946, 422). This action is forward looking and indicates an awareness of present and future problems in the discovery and wise exploitation of supplies of the chemical elements both common and rare. Other educational institutions are organizing groups of teachers and research workers with similar objectives.

It is, indeed, true that geochemistry is becoming recognized in American academic institutions as a borderline field worthy of intensive study and research.

It is also true that geochemistry, under that name, has not, in the past, been widely recognized by American scientists. However, the neglect has not been so marked as to justify the statement, "For the first time in the history of American academic institutions a course in geochemistry will be given at Penn State."

Research in geochemistry, particularly as it applies to the less familiar elements, has been conducted at Purdue University under the direction of D. W. Pearce since 1935. (H. B. HASS, *head, Department of Chemistry, Purdue University, Lafayette, Indiana.*)

There are certain fundamental objectives to an organized program of cancer research. As Dr. Kosolapoff points out (*Science*, November 22, p. 491), our military use of nuclear explosives was due to an accidental discovery that a particular nucleus, under a particular treatment, would result in a fission of special properties, especially needed at the time. As Dr. Kosolapoff says, "On the basis of knowledge in the 1930's the finding of such a nucleus may well be called fortuitous."

He says that in the case of penicillin chance determined the first observation of antibiotic effects, but once the goal was perceived, mass methods in taking advantage of the fortuitously acquired knowledge was a foregone conclusion.

He points out that cancer research is not analogous to the programs of research and development in the fields of atomic fission and penicillin because in these latter projects the basic discoveries had already been made and only required "development," which could be accomplished fairly rapidly by mass effort.

This statement carries a great deal of truth, but as far as penicillin is concerned, it is not the whole truth. It is indeed true that Fleming's original observation of a *penicillium* contaminant on an agar plate inoculated with mold-sensitive staphylococci was the result of chance. Yet 11 years elapsed before Chain, Florey, *et al.* at Oxford initiated the further research which was ultimately to demonstrate the clinical possibilities of penicillin and to stimulate American workers to solve difficult problems of production.

Why did a delay occur? Because the basic observation was not enough to do more than suggest the possibilities ahead!

Further research was needed before the goal could even be seen very clearly. In the meantime, 11 years were lost because no one happened to have the right combination of motivation and equipment to follow an interesting lead.

Yet, if there had happened to be in progress an all-out search for some therapeutic agent for combating staphylococcus septicemia, this lead would certainly have been explored much earlier.

Dr. Kosolapoff next points out that there is no clearly defined line of approach to a solution of the cancer problem. This also is doubtless true, but there are certainly some promising observations that justify further exploration as much as did Fleming's original observations on penicillin.

To mention only two, we may note the selective effect of impure penicillin on sarcoma cells in tissue culture and the reported inhibiting effect of certain estrogenic substances on carcinoma of the prostate in males.

There are others of equal or greater significance.

But even if there were none, it is hard to see how that fact could constitute an argument against a well-organized National Cancer Research Program.

There are numerous opportunities for fundamental research. Two promising fields for investigation are: the use of the radioactive tracer technique in a study of the metabolism of normal and malignant cells; and an investigation of the blocking of certain enzyme systems of mammalian cells in tissue culture by structural analogues.

This is not to say that competent investigators are not already working along these lines, as well as others, equally promising. But the problem is too big, and the need too great, to leave it all to uncoordinated individual groups. There is no reason why the necessary *fundamental research,* cannot be expedited by well-directed teamwork as well as the so-called *development* phases.

Dr. Kosolapoff suggests that because we do not *yet* see an obvious approach that is bound to lead to a practical solution, there is nothing to be gained by a mass effort.

It is my contention that there are worth-while leads crying to be followed and that there is fundamental work which, when completed, cannot fail to suggest other lines of approach. If all of this work is left to be accomplished by a leisurely peacetime research program, it may take decades. There is a serious shortage of well-trained investigators in this field which will still further hamper this work. What is to stimulate increased interest and provide for the training of the number of new workers needed if not a national program of cancer research? It is well recognized that fundamental research provides the new observations and discoveries which serve as a basis for the development of new applications!

Fundamental research in the case of cancer does not have to proceed slowly because of a lack of new ideas. There are plenty of them. It is slow because of the shortage of personnel, facilities, and funds. Given these, the now difficult experimental techniques will become simple procedures. (K. S. PILCHER, *associate director of research, Cutter Laboratories, Berkeley, California.*)

Book Reviews

Women in industry: their health and efficiency. Anna M. Baetjer. (Issued under the auspices of the Division of Medical Sciences and the Division of Engineering and Industrial Research, National Research Council.) Philadelphia-London: W. B. Saunders, 1946. Pp. xi + 344. (Illustrated.) $4.00.

Over the period of the last 100 years there was a steady increase, both in absolute figures and relatively with respect to men, in the number of gainfully employed women. In the United States, by 1900, about 5,000,000 women were employed; in 1940 the number increased to 12,000,000. The trend has been accelerated by the war, the number reaching some 18,000,000 in 1945. A particularly marked increase occurred in the number of women employed in industry.

The personnel man, the production engineer, the industrial physician, the public health officer, and the insurance agent have become more acutely concerned with women's occupational fitness and with the effects of the industrial work on health. It was in response to this growing demand for a critical and systematic summary of available information on problems specifically connected with the employment of women in industry that Dr. Baetjer's book was written.

Most of the material is based on statistical data concerning such characteristics of industrial populations as sickness absenteeism, accidents, morbidity, and mortality. It is a well-established fact that men throughout the employable age range have a significantly higher mortality rate than women. However, the causative factors are not understood well enough to allow a safe prediction of changes in the mortality rate of women resulting from the increased industrial employment.

In contrast to mortality, women have a higher apparent morbidity. They are absent more frequently and lose more time. The yearly absences average from 7 to 11 days per woman as compared with 2 to 7 days per man. This difference in the incidence of absences reported and recorded as "sickness absenteeism" do not necessarily reflect a constitutional difference in the susceptibility to disease, *i.e.* differences which would be present if the accessory factors, such as the household duties of the women and financial responsibilities of the men, were equated.

The reported causes of sickness absenteeism in the great majority of instances are common to the two sexes, 50 per cent of absences being accounted for by respiratory diseases and 20 per cent by digestive diseases. Gynecological disturbances play a minor role; the loss of time due to dysmenorrhea is small and can be further reduced by appropriate methods. Pregnancy definitely limits the capacity for heavy work and increases the danger of exposure to toxic factors, such as lead. Beyond these facts no generalization can be made, and the continued employment of a pregnant employee is essentially an individual medical problem.

Except for the effect of some toxic agents in pregnancy, there is no adequate evidence that women have a greater susceptibility to occupational diseases than men. Industrial accidents do not contribute significantly to women's absenteeism; the lower rate of industrial accidents of women as compared with men is attributable to a difference in exposure.

In reference to women's physical "fitness" the following mean values are quoted, expressed as percentages of the men's mean: height, 93; weight, 81; pull, 51; and grip, 53 per cent. Even though the interindividual differences between women are great and can be utilized in the process of scientific placement, the employment of large numbers of women should lead to a redesigning of the work place, machines, and tools. Although the author reports, with special reference to women's record in World War II, that properly trained women were essentially equal to men in all types of industrial activities, except for their handicap in heavy work, and were especially capable at jobs requiring manual dexterity and fine coordination, the statistics are singularly absent.

The basic philosophy of the book is sound. It places emphasis on proper selection, placement, training, and supervision. An adequate placement is one of the key points in an efficient utilization of man power. It involves a skillful appraisal of the physical, mental, and emotional characteristics of the applicants and requires a close coordination between the medical and the personnel department. Dr. Baetjer does not point out the inadequacy of the present methods of medical diagnosis of occupational fitness and the dearth of follow-up studies necessary for the clarification of the relationship between pre-employment "fitness," production efficiency, and effects of work on health.

This review represents a useful summary of an important sector of the science of human work. Its value consists as much in the able and critical sifting of the available and often contradictory data as in pointing out, directly and indirectly, the large gaps in our knowledge about the interrelationships between health and industrial work. In addition to group statistics there is an urgent need for information obtained by means of controlled observation and experimental analysis.

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Enzymes and their role in wheat technology. J. Ansel Anderson. (Ed.) (American Association of Cereal Chemists Monogr. Ser., Vol. I.) New York: Interscience Publishers, 1946. Pp. ix + 371. (Illustrated.) $4.50.

This volume represents the efforts of two distinct types of research workers, the academic and the industrial. In general design it consists of a systematic review of five major enzyme fields, each of which is first reviewed as a whole and then, in a second chapter, related to wheat technology. Although designed primarily for grain specialists, the book has a far wider appeal, providing, as it does, comprehensive reviews on various branches of enzymology, including amylases, esterases, respiratory enzymes, proteases, and fermentative enzymes.

Half of the book, then, is unrelated to wheat technology and

provides a general introduction to enzymology of distinct value in its own right. The other chapters, written for the grain specialist, undoubtedly will be of great value both as text and reference source.

The five chapters dealing with the industrial application vary more between themselves than do the uniformly excellent general survey articles. Basically, this inequality derives from the ambitious design of the book, whereby the full range of enzymology is discussed from one limited application, viz., breadmaking. It is thus inevitable that some fields, such as esterases and proteases, provide their technological reviewers with less material than do others, such as fermentation enzymes.

It is also probably inevitable that 15 contributors should use the word "enzyme" in quite different ways, no particular effort being made to distinguish between isolated enzymes with proven characteristics and the enzymes which are presumed to be present in the living cells by virtue of the recognition of certain metabolic processes. Indeed, the 15 or so enzymes described in the final chapters on yeast fermentation are referred to in the opening chapter as the single enzyme, "zymase."

Despite these minor criticisms, the book should immediately become a standard text for all cereal chemists, especially in view of the excellent bibliographies included with each review. These include the titles of the original papers—a practice that has much to recommend it. Author and subject indexes are provided.

W. Farnsworth Loomis

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The people look at radio. Paul F. Lazarsfeld and Harry Field. Chapel Hill: Univ. North Carolina Press, 1946. Pp. ix + 158. (Illustrated.) $2.50.

This is a report of a survey which was planned in part by the National Association of Broadcasters (the sponsors of the study) and in part by Denver's National Opinion Research Center. NORC, under the direction of the late Harry Field, was responsible for polling a cross-section sample of over 3,000, and the resulting data were analyzed, interpreted, and reported by Lazarsfeld. Over a third of the volume is devoted to appendices which include characteristics of the sample, percentage tables for responses to the questions, and percentage tables for breakdowns and cross-tabulations.

Apparently the people think that radio is doing a better job than such institutions as the newspaper, church, school, and local government, yet about two-thirds of the people are critical of some phase of radio. It may surprise some readers to learn that a third are never annoyed by the radio, and that less than a third of those who are critical voice objections to radio advertising. For evening listeners, news broadcasts lead the list of preferred programs, followed in order by plays, comedy, quiz, old familiar music, talks and discussions, classical music, etc. It would seem that only 50 per cent of the people know that the Government has anything to do with the operation of radio; two-thirds would have the Government see to it that news broadcasts are truthful and that both sides of public issues be given. Of those who expressed definite opinions, four out of five think that the radio gives fairer, more unbiased news than the newspapers; 81 per cent believe the radio fair in presenting both sides of issues, whereas only 39 per cent so regard the newspapers.

These and other over-all findings plus interrelationships indicate that one of the tools of the social scientists—opinion surveying on a sampling basis—can lead to results which are of interest to the student of the American scene. It is not easy to determine the extent to which the results of this study need qualifications because of the difficulties of the polling operation, which the reviewer has discussed elsewhere (*Psychol. Bull.*, 1946, **43**, 289–374).

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Scientific Book Register

Anderson, Arthur K. ***Essentials of physiological chemistry.*** (3rd ed.) New York: John Wiley; London: Chapman & Hall, 1947. Pp. vii + 395. (Illustrated.) $3.50.

Barnes, H. F. ***Gall midges of economic importance.*** Vol. I: ***Gall midges of root and vegetable crops;*** Vol. II: ***Gall midges of fodder crops.*** London: Crosby Lockwood & Son, 1946. Vol. I: Pp. 104; Vol. II: Pp. 160. (Illustrated.) 12/6; 15/-.

Cooke, Robert A. ***Allergy in theory and practice.*** Philadelphia-London: W. B. Saunders, 1947. Pp. xxv + 572. (Illustrated.) $8.00.

Friedmann, Herbert (commenced by the late Robert Ridgway). ***The birds of North and Middle America.*** (Pt. X.) (Smithsonian Institution, U. S. National Museum Bull. 50.) Washington, D. C.: Government Printing Office, 1946. Pp. xii + 484. (Illustrated.) $1.25.

Jones, W. Norton, Jr. ***Inorganic chemistry.*** Philadelphia-Toronto: Blakiston, 1947. Pp. xii + 817. (Illustrated.) $4.25.

Knight, J. Brookes. ***Some new Cambrian bellerophont gastropods.*** (Smithsonian Miscellaneous Collections, Vol. 106, No. 17.) Washington, D. C.: Smithsonian Institution, 1947. Pp. 11. (Illustrated.)

Munroe, Helen. (Compiler.) ***Classified list of Smithsonian publications available for distribution December 1, 1946.*** (Publ. 3858.) Washington, D. C.: Smithsonian Institution, 1946. Pp. 53.

Pelseneer, Jean. ***Morale de savants: d'Hippocrate à Einstein.*** Brussels: Office de Publicité, 1946. Pp. 128.

Prata, Emidio. ***La scissione nucleare dell'uranio: fenomenologia generale.*** Milan: Ulrico Hoepli, 1946. Pp. 160.

Strong, Ralph K. ***Chemistry for the executive: a layman's guide to chemistry.*** New York: Reinhold, 1946. Pp. 445. (Illustrated.) $6.00.

Wetmore, Alexander. ***New birds from Colombia.*** (Smithsonian Miscellaneous Collections, Vol. 106, No. 16.) Washington, D. C.: Smithsonian Institution, 1946. Pp. 14.

———. ***Catalogue of films of general scientific interest available in Great Britain.*** (Compiled by the Scientific Film Association.) London: Association of Special Libraries and Information Bureaux, 1946. Pp. 188.